DIG THIS: SOIL FROM A MARTIAN MOON

AIR&SPACE Smithsonian

Airplanes in Bond Flicks

WHICH ONE'S COOLEST?

BD-5J Micro-jet
from *Octopussy*

Up, Down, or Dead? How Vertigo Kills Pilots

The Air-Brained Marx Brother (p. 22)

SEPTEMBER 2008

The Fifth C?

Cut, Color, Carat, Clarity...Chemistry?

Is it possible that the mind of a scientist can create more beauty and romance than Mother Nature? The laboratories at Diamond*Aura*™ were created with one mission in mind: *Create brilliant cut jewelry that allows everyone to experience more clarity, more scintillation and larger carat weights than they have ever experienced.* So, we've taken 2.5 carats of our lab-created Diamond*Auras* and set them in the most classic setting—the result is our most stunning, fiery, faceted design yet! In purely scientific measurement terms, the refractory index of the Diamond*Aura* is very high, and the color dispersion is ***actually superior*** to mined diamonds.

Compare For Yourself at 2.5 carats

	Mined Flawless Diamond	Diamond*Aura* Compares to:
Hardness	Cuts Glass	**Cuts Glass**
Cut (58 facets)	Brilliant	**Brilliant**
Color	"D" Colorless	**"D" Colorless**
Clarity	"IF"	**Clear**
Dispersion/Fire	0.044	**0.066**
2.5 c.t.w. ring	$60,000+	**$145**

Perfection from the laboratory. We named our brilliant cut stones Diamond*Aura*, because, "they dazzle just like natural diamonds but without the outrageous cost." We will not bore you with the incredible details of the scientific process, but will only say that it involves the use of rare minerals heated to an incredibly high temperature of over 5000˚F. This can only be accomplished inside some very modern and expensive laboratory equipment. After several additional steps, scientists finally created a clear marvel that looks even better than the vast majority of mined diamonds. According to the book *Jewelry and Gems–the Buying Guide*, the technique used in Diamond*Aura* offers, *"The best diamond simulation to date, and even some jewelers have mistaken these stones for mined diamonds."*

The 4 C's. Our Diamond*Aura* 3-Stone Classique Ring retains every jeweler's specification: color, clarity, cut, and carat weight. The transparent color and clarity of Diamond*Aura* emulate the most perfect diamonds—D Flawless, and both are so hard they will cut glass. The brilliant cut maximizes the fire and radiance of the stone so that the light disperses into an exquisite rainbow of colors.

Rock solid guarantee. This .925 sterling silver ring is prong-set with a 1.5 carat Diamond*Aura* round brilliant in the center, showcased between two Diamond*Aura* round brilliants of .48 carats each. Adding to your 4 C's, we will include the Diamond*Aura* stud earrings for FREE! Try the Diamond*Aura* 3-Stone Classique Ring for 30 days. If for any reason you are not satisfied with your purchase, simply return it to us for a full refund of the purchase price and keep the stud earrings as our gift.

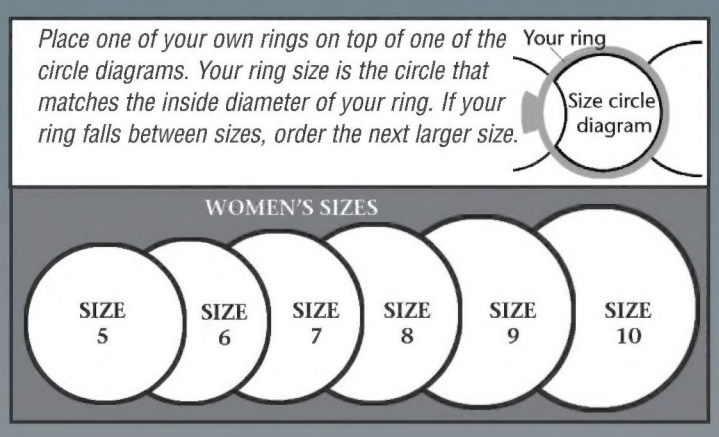
Not Available in Stores

Diamond*Aura*™ 3-Stone Classique Ring
(2.5 c.t.w) • **$145** + S&H
FREE *stud earrings with purchase of Classique Ring*—a $59.95 value!
Available in ring sizes 5-10

Call to order toll-free, 24 hours a day, 7 days a week.

1-888-201-7095

Promotional Code DAR296-02
Please mention this code when you call.



Stauer
Heritage of Art & Science
14101 Southcross Drive W., Dept. DAR296-02
Burnsville, Minnesota 55337

Visit us online at www.Stauer.com for the complete line of Stauer Watches, Jewelry and Collectibles

"The color and clarity of DiamondAura rivals that of a flawless D-colored diamond".

—Steven Rozensky

Noted jewelry expert

Receive these scintillating Diamond*Aura*™ Classique sterling silver stud earrings FREE!

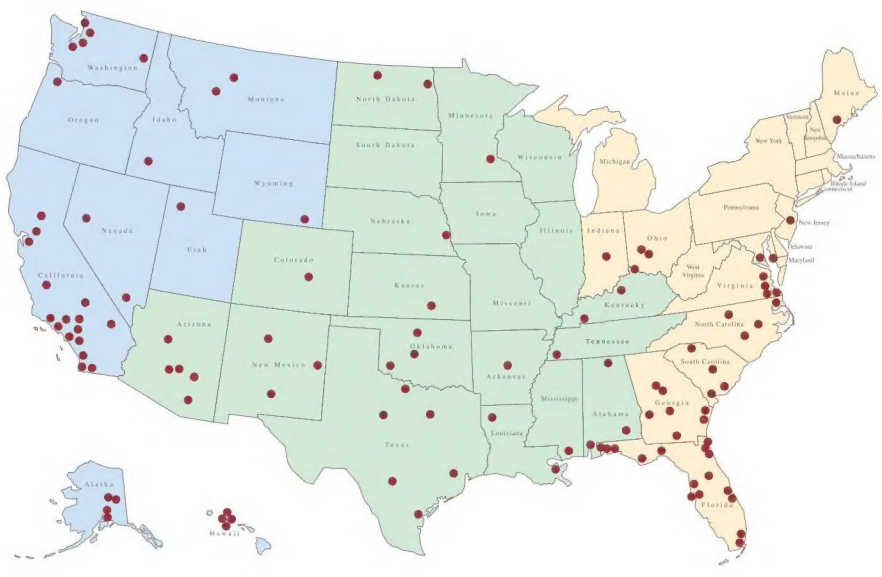
Read details left.

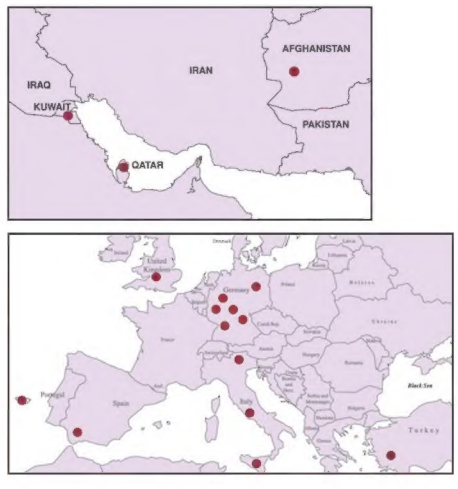
For fastest service, call toll-free 24 hours a day 888-201-7095

YOUR WORLD. WIDE OPEN.

Embry-Riddle Aeronautical University is where you are – at more than 130 locations across the country, around the world and online. From Berlin to Los Angeles, Houston to Cincinnati, Daytona Beach to Prescott, Embry-Riddle delivers an accredited, world-class university education in the classroom or online.

Designed for the working professional in the aviation, aerospace, technology or transportation industries, our programs will position you for success.





WORLDWIDE • DAYTONA BEACH, FL
PRESCOTT, AZ • ONLINE

EMBRY-RIDDLE
aeronautical university
Worldwide

www.embryriddle.edu/yourworld

(866) 478-4870

IT IS IN THE THERMAL SUIT, THE POLYCARBONATE HELMET, THE ROCKET FUEL, THE THINGS THAT WILL LAUNCH US INTO THE FUTURE. IT IS AMERICAN CHEMISTRY.

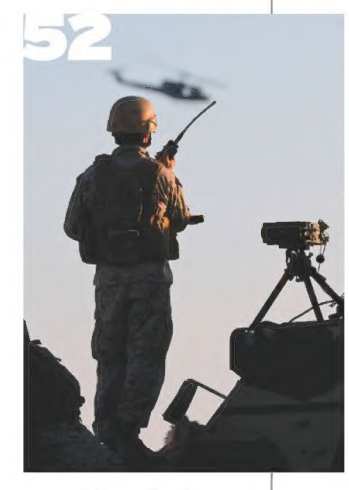
americanchemistry.com
essential

August/September 2008 | Vol. 23, No. 3

AIR&SPACE Smithsonian

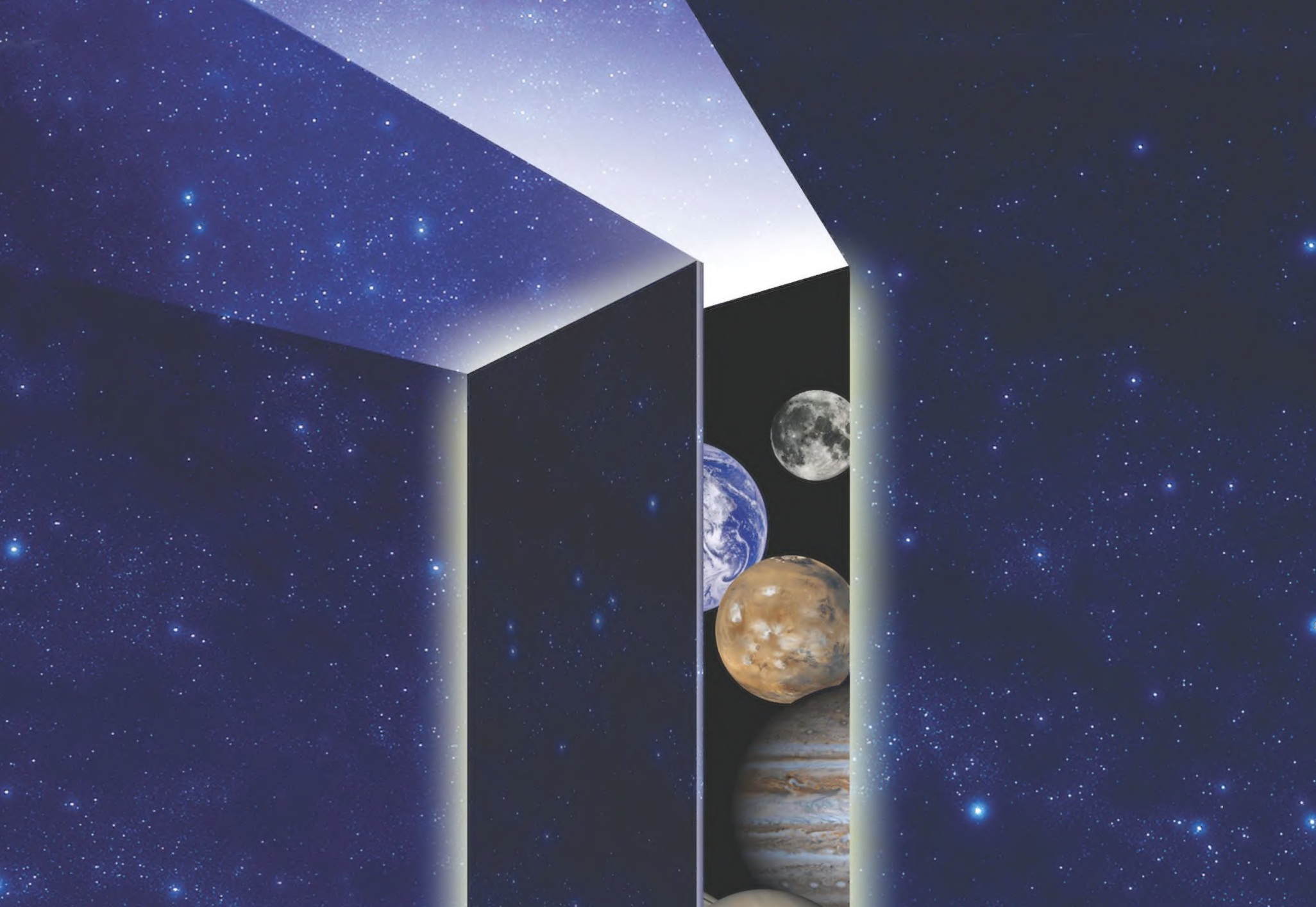
ON THE COVER: Last seen flying through a hangar in the Bond film *Octopussy*, J.W. Fornof's BD-5J has entertained thousands at airshows. Our own special effects wizard tripled the image in a photograph by Tom Trinkwalder to increase the micro-jet's odds against evildoers. What will fly in this fall's Bond flick? See p. 28.

Features



Departments

On the Web Site www.airspacemag.com
With all eyes on Beijing for the summer Olympics, we offer profiles of aviators who pioneered flight in China. Our redesigned site now has a searchable archive of every magazine feature published since 2001.



OPENING DOORS OF WONDER FOR 50 YEARS.

As we join in celebrating the 50th anniversary of NASA, we salute the men and women whose unwavering commitment to the exploration of space has forever changed the world.

BOEING

Viewport

FROM THE DIRECTOR

Cool Moves

AUGUST IS THE PERFECT TIME to visit the National Air and Space Museum. Yes, Washington, D.C., is known to get pretty hot and humid, but the Museum on the National Mall and the nearby Steven F. Udvar-Hazy Center in Virginia are two of the coolest places in the metropolitan area. I mean that figuratively as well as literally. What makes our buildings so cool of course are the rare, historic, and record-setting aircraft and spacecraft that fill them. Displaying these artifacts, however, is a job that has sometimes made us sweat.

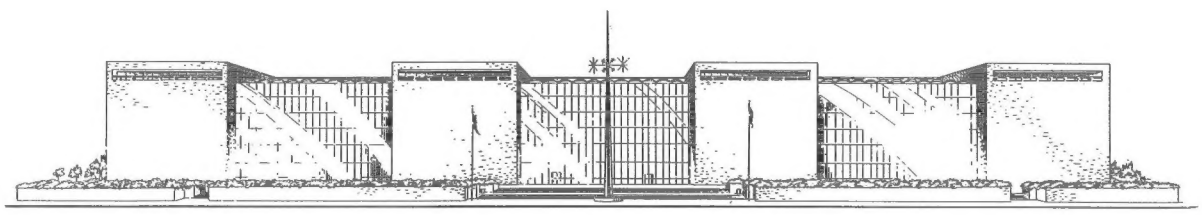
In the five years since the Udvar-Hazy Center opened, for example, the number of artifacts showcased there has doubled. Eventually, 220 aircraft and 150 spacecraft will occupy the nearly six acres of concrete floor or hang at varying heights from the 10-story-high ceiling. With so many artifacts to display, we must consider how placement can show off the unique features of each one without blocking the display of others. Before determining placement, we first verify the dimension, center of gravity, weight, and appropriate hanging points for each major artifact. We then create a computer drawing for each one and combine it with computer models of the hangars. Finally, we create a computer rendering to show the displays from the visitor's perspective and to give us one last opportunity for fine-tuning an installation.

Even with careful planning, we've had surprises. The Redstone missile on display in the James S. McDonnell Space Hangar, for instance, turned out to be seven feet taller than we originally thought. For decades it was stored in a sealed container at the Museum's restoration facility. Records indicated that the rocket—originally designed to carry a nuclear warhead, then modified to launch a Mercury capsule—was a 62-foot-tall prototype. However, when the rocket was being restored for display in 2004, we discovered that it was actually a 69-foot production model with panels removed to let visitors see inside. Museum staff were able to position the Redstone—its tip within inches of the ceiling—where it could best be viewed.

As we continue to move airplanes and spacecraft into the Udvar-Hazy Center, our work becomes more challenging. Floor space is dwindling and available hanging points are more difficult to reach. And we have set a high standard to give each artifact its most dynamic, compelling display.

Upon entering the Center, visitors encounter a World War II Curtiss P-40 Warhawk in an attack dive, while nearby a Vought F4U Corsair simulates a carrier landing. Aerobatic aircraft appear frozen in flight, and overhead three sailplanes, hung close together, seem to be tracking air currents that flow through the building. All of these installations constitute a finely choreographed ballet of heavy equipment and priceless artifacts. We invite you to enjoy the result.

J.R. DAILEY IS THE DIRECTOR OF THE NATIONAL AIR AND SPACE MUSEUM.



AIR&SPACE Smithsonian

Editor	Linda Musser Shiner
Executive Editor	Paul Hoversten
Senior Editors	Tony Reichhardt Patricia Trenner
Senior Associate Editor	Perry Turner
Associate Editors	Michael Klesius Rebecca Maksel Diane Tedeschi
Photography and Illustrations Editor	Caroline Sheen
Researcher	Roger A. Mola
Graphic Design	Ted Lopez, Eason Associates, Inc.
Founding Editor	George C. Larson

EDITORIAL: (202) 633-6070
e-mail: *editors@si.edu*
Web site: *www.airspacemag.com*

Air & Space/Smithsonian; August/September 2008; Volume 23, Number 3

Air & Space/Smithsonian (ISSN 0886-2257) is published bimonthly by Smithsonian Business Ventures, MRC 513, PO Box 37012, Washington, DC 20013-7012. Periodical postage paid at Washington, DC, and additional mailing offices.

POSTMASTER: Send change of address to *AIR & SPACE/Smithsonian*, PO Box 420113, Palm Coast, FL 32142-0113. Printed in the USA. Canadian publication agreement no. 40039324. Canadian return address: Brokers Worldwide, PO Box 1051, Fort Erie, ON L2A 6C7 Canada.

 Editorial offices: MRC 513, PO Box 37012, Washington, DC 20013. Circulation and advertising offices: 420 Lexington Ave., New York, NY 10170.

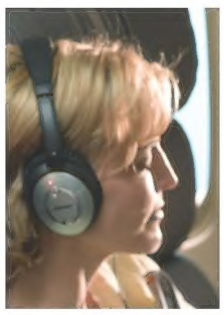
Subscription Prices: U.S. and possessions: $26 a year payable in U.S. funds. Canada and all other countries: add $6.00 (U.S. funds) per year. Ninety-nine percent of dues is designated for magazine subscription. To purchase an issue (current $4.99, back issue $7), please write *AIR & SPACE/Smithsonian*, 420 Lexington Ave., Suite 2335, New York, NY 10170, or call (212) 916-1379.

Mailing Lists: We sometimes make our subscriber list available to companies that sell goods and services that we believe would interest our readers. If you do not want to receive such mailings, send your current mailing label or, an exact copy, to: *AIR & SPACE/Smithsonian*, Mail Preference Service, PO Box 420113, Palm Coast, FL 32142-0113.

Address Changes and Subscription Orders: mail to *AIR & SPACE/Smithsonian*, PO Box 420113, Palm Coast, FL 32142-0113; call (800) 766-2149; outside the U.S., call (386) 447-2721.

The Bose® QuietComfort® 2 Acoustic Noise Cancelling® Headphones.

Think of them as a peaceful getaway from the world around you. Whether it's the engine roar inside an airplane cabin, the bustle of the city or the distractions in the office, Bose QuietComfort 2 headphones help them fade softly into the background with the flick of a switch. You can savor delicate musical nuances without disturbing others. And when you're not listening to music, you can slip into a tranquil haven – where you can relax and enjoy peace and solitude. Clearly, these are no ordinary headphones. It's no exaggeration to say they're one of those things you have to experience to believe.



Use them as a concert hall – or a sanctuary.

"It's as if someone behind your back reached out, found the volume control for the world, and turned it way, way, down," reports *TechnologyReview.com*. Bose QC®2 headphones incorporate patented technology that electronically identifies and dramatically reduces noise, while faithfully preserving the music, movie dialogue or tranquility you desire. We designed these headphones primarily for airplane travelers. But owners soon started telling us how much they enjoy using them in other places to reduce distractions around them. They're excellent for listening to music whether you're on the go, at home or in the office.

"Forget 'concertlike' comparisons; you'll think you're onstage with the band." That's what *Travel + Leisure Golf* said when these headphones were first introduced. You'll relish the sound of a bass guitar. Or a flute. Or the delicate inflections of a singing voice. The audio is so clear you may find yourself discovering new subtleties in even your favorite music.

"The QuietComfort 2 lives up to its name, enveloping you in blissful sound in the utmost comfort. It's easy to forget they are on your head." That's what respected columnist Rich Warren reports. To enjoy peace and tranquility, simply turn them on. To add Bose quality sound, attach the included audio cord and connect them to a laptop computer, portable CD/DVD/MP3 player, in-flight audio system or home stereo. They also offer a fold-flat design for easy storage in the slim carrying case.

Try the QC2 headphones for yourself, risk free. You really must experience them to believe it. Call toll free to try these headphones for 30 days. Use them on your next trip, in your home or at the office – satisfaction guaranteed. If you aren't delighted, simply return them for a full refund.

Call 1-800-901-0256, ext. Q6585 today. The QC2 headphones are available directly from Bose – the most respected name in sound. When you call, ask about making **12 easy payments,** with no interest charges from Bose.* And discover a very different kind of headphone – QuietComfort 2 Acoustic Noise Cancelling headphones.

FREE shipping with your order.

To order or learn more:

1-800-901-0256, ext. Q6585

www.Bose.com/QC

BOSE®

Better sound through research®

*Bose payment plan available on orders of $299-$1500 paid by major credit card. Separate financing options may be available for select products. See website for details. Down payment is 1/12 the product price plus applicable tax and shipping charges, charged when your order is shipped. Then, your credit card will be billed for 11 equal monthly installments beginning approximately one month from the date your order is shipped, with 0% APR and no interest charges from Bose. Credit card rules and interest may apply. U.S. residents only. Limit one active financing program per customer. ©2008 Bose Corporation. Patent rights issued and/or pending. The distinctive design of the headphone oval ring is a trademark of Bose Corporation. Financing and free shipping offer not to be combined with other offers or applied to previous purchases, and subject to change without notice. Risk free refers to 30-day trial only and does not include return shipping. Delivery is subject to product availability. Quotes reprinted with permission: Simson Garfinkel, *TechnologyReview.com*, 7/9/03; *Travel + Leisure Golf*, 7/03; Rich Warren, *News-Gazette*, 5/19/03.

Letters

WRITE TO US

A Healed Breach

For five years in the 1980s, I was an A-10 pilot and operations officer stationed at Norvenich, Germany, near Cologne. One day back then, I took my family to one of our "targets" in the Gottingen Corridor and the Fulda Gap, a trip similar to the one described in "The Bridge That Did Not Fall" (Above & Beyond, June/July 2008). We had to study those sites very well from the air and on the ground, as they were the Western approaches for the Warsaw Pact tanks to penetrate into West Germany. I walked my family through the woods up to, but not across, the Inner German Border (IGB). The family was impressed and awed by the line, the signs, the barbed wire fences, the mine fields, the guard towers, and the dog runs. The guards cautiously watched us with binoculars and took our pictures, and we took theirs. We then went to a hill overlooking the small town of Duderstadt. Sadly, it was right on the IGB; half of the city was cut off from the West. Railroad tracks were cut, buildings were boarded up, and fencing and guard towers separated the city from itself. The West was prosperous and thriving; the East was desolate and empty.

My wife and I recently revisited central Europe. There was no sign that that border ever existed. Churches were open, shops and restaurants bustled with activity. The little town is now beautiful and thriving.

Lt. Col. James M. Bruchas
U.S. Air Force (ret.)
Lake St. Louis, Missouri

A Different Angle

One airplane that you did not mention in "How Things Work: Thrust Vectoring" (June/July 2008) is the F-15 STOL Maneuver Technology Demonstrator. This program was designed to demonstrate short-takeoff-and-landing capability on bomb-damaged runways. The aircraft had canards, as well as the capacity for vertical thrust vectoring and thrust reversing. The Air Force and its contractors completed the demonstration at Edwards Air Force Base in California, then turned the aircraft over to NASA for further vectoring development.

Jerome C. Brandt
Chico, California

It Took a Lickin'...

"Lockheed's Missing Link" (June/July 2008) had a brief reference to a B-17 that was the only aircraft to fly out after the nuclear tests. That B-17 (serial no. 44-83575) is still flying. In addition to the years on the Yucca Flats after the tests, it had some tough times before Globe Air Service purchased it. Later, it was sold to the Collings Foundation, and while flying an airshow in Beaver County, Pennsylvania, it went off the end of the runway and down a ravine, sustaining substantial damage. The aircraft was returned to flying and has remained relatively trouble-free since, proving that you can't keep a good plane down. (I was its pilot/crew chief from 1993 to 1996.)

Scott Johnson
via e-mail

Jet Blindness

Your "Aircraft That Changed the World" (June/July 2008) is certainly disappointing. The biggest change in aircraft during the last century was the invention of jet propulsion. Yet you didn't include the world's first experimental jet-powered airplane, the Heinkel 178, which took off over a forest in Germany on August 27, 1939.

Armin W. Becker
Ormond Beach, Florida

Editors' note: For another list of provocative picks, see "Airplanes That Transformed Aviation" by aviation historian Richard Hallion, posted on our Web site (www.airspacemag.com).

AIR&SPACE Smithsonian

Smithsonian Institution

PUBLISHING GROUP

President	Thomas Ott
Executive Asst. to the President	James A. Babcock
General Manager	Alan Chu
Group Publisher	Kerry Bianchi
ADVERTISING	(212) 916-1300
Ad. Services Manager	Marilyn Cruz
New York	Diantha W. Redd, Sales Director, Mary Jo Boudinot, Suzanne Grossman
Midwest	Bill Milligan, Lara Esquivel, Jeff Orr
Detroit	Colleen Maiorana, Holly Wilcox
Southwest	Steve Moynihan, Lindsay Davis
Southeast	Kelly Hediger, Lisa Herlan
West Coast	Kate Knox, Charles Carroll
Mid-Atlantic	Christine Hoisington
Florida	Colleen Schoch
Caribbean/Cent. Amer.	Al Nadal
Mexico	Elsie Mendez Eriquez, Victor Ocadiz
Canada	Richard Brown, Cindy Ratych, David Seaberg, Greg M. Smith
London	Graeme Brown
Japan	Yoshinori Ikeda, Shigenori Nagatomo
Thailand	Yvan Van Outrive, Ja Pipatra
Korea	S.S. Song
Direct Response	MI Media Services, LLC
Interactive	Andrea Basche
Advertising Assistants	Blythe Graham-Jones, Amanda ReCupido

MARKETING/RESEARCH

Director of Marketing	Rosie Walker
Associate Art Director	Natalie Thompson
Assoc. Dir. of Sales Development	Christine Staley Corr
Marketing Manager	Laurie A. Corson
Promotion Manager	Karen Mendolia
Assoc. Marketing Mgr.	Caitlin McCarthy
Research Director	Renee Mitchell
Research Manager	Marilyn Resciniti

CONSUMER MARKETING

Consumer Marketing Director	Lisa Dunham
Planning Director	Elizabeth M. Hopkins
Fulfillment Director	Andrea Sole
Forecast Manager	Donald G. Dodd
Purchasing Manager	Suzanne L. Eng
Direct Mail Manager	Lori Paldino
Gift Manager	Joanne Marrero
Renewals Marketing Coordinator	Matthew Troxel
Direct Mail Coordinator	Laura E. Vichick

ONLINE PUBLISHING GROUP

Sr. Web Producer	Kelly Durkin
Interactive Ad Operations Coordinator	Matthew Feldman
Jr. Producer	Cheryl Carlin

MANUFACTURING

Director	Sarah D. Kingsley
Postpress Director	Greg Williams
Prepress Director	Katherine Balch
Prepress Manager	Frank Matthew Hale II
Prepress Manager	Marie Prete
Color and Quality Mgr.	Stanley Boone
Adv. Systems Manager	Penie Atherton-Hunt

BUSINESS OFFICE

Business Manager	Ed Dequina
Accountant	Beth Cunigan

SMITHSONIAN ENTERPRISES

Acting President	Thomas Ott

One day, his son would speak to the world.

He wanted them to understand.

Rosetta Stone.® The fastest and easiest way to learn CHINESE.

Arabic • Chinese (Mandarin) • **Danish • Dutch • English** (American) • **English** (British) • **Farsi** (Persian) • **French • German • Greek**
Hebrew • Hindi • Indonesian • Italian • Irish • Japanese • Korean • Latin • Pashto • Polish • Portuguese (Brazil) • **Russian**
Spanish (Latin America) • **Spanish** (Spain) • **Swahili • Swedish • Tagalog** (Filipino) • **Thai • Turkish • Vietnamese • Welsh**

Discover a whole new world with Rosetta Stone,® the world's leading language-learning software. Only Rosetta Stone uses Dynamic Immersion® to teach you a language quickly and efficiently, without tedious translation and grammar drills.

- You'll experience our **Dynamic Immersion** as you match real-world images to words spoken by native speakers. There is no translation or memorization. Instead, you become quickly engaged, the way you learned your first language... for a faster, easier way to learn.
- Our patent-pending **Speech Recognition Technology** evaluates your speech and coaches you to more accurate pronunciation, so you'll be speaking faster and more naturally.
- And only Rosetta Stone has **Adaptive Recall™** which tracks your progress and then customizes every lesson based on your individual needs, for faster and more effective learning.

Discover Rosetta Stone - **The Fastest Way to Learn a Language. Guaranteed.™**

100% GUARANTEED
SIX-MONTH MONEY-BACK

SAVE 10%

Level 1	~~$209~~	**NOW**	**$188.10**
Level 1&2	~~$339~~	**NOW**	**$305.10**
Level 1,2&3	~~$499~~	**NOW**	**$449.10**

Call
(877) 231-9474

Online
RosettaStone.com/ais088

Use promotional code ais088 when ordering.
Offer expires December 31, 2008.

RosettaStone®

Okay, okay...

The response to "Aircraft That Changed the World" (June/July 2008) has been mixed: Some of you thought we were crazy for not including the Douglas DC-3, while others thought we were idiots.

"I think you really blew it," declared Colonel Sigmund Alexander, U.S. Air Force (ret.). "Before the DC-3, air travel was an uncomfortable and sometimes hazardous venture." Paul Day pointed out that the DC-3 "was, after all, the first really profitable modern airliner, and some are still flying." Bob Franz sent us his "suggested changes," which went "First, deletions: Junkers F13, MiG -15, and Learjet. My substitutions: Douglas DC-3; Britain's first jet, the Gloster E.28/39; and the Rutan Voyager." "I feel that the Douglas DC-3 must be included in any list like this," Jerry Elmas insisted. "The DC-3 introduced air travel to the masses." And one newspaper account of our article ended simply with "Hello? The DC-3?"

11. Douglas DC-3

THE DOUGLAS DC-3 saved the airline industry, which, in the 1930s, was funded largely by government airmail subsidies; ticket sales brought in merely beer money. But the "Three," as airlines came to call the transport, provided enough seats, speed, and range to make carrying passengers profitable. "By 1938," notes the National Air and Space Museum, "95 percent of all United States—and 90 percent of the world's—commercial airline traffic was in DC-3s." The military version, the C-47, is famed as a World War II troop carrier, Berlin Airlift cargo hauler, Korean War transport, and Vietnam War gunship. Douglas churned out some 800 DC-3s and more than 10,000 C-47s; another 2,060 were built under license in Russia and Japan. Braniff Airways captain and *Flying* magazine writer Len Morgan wrote memorably of the -3: "It groaned, it protested, it rattled, it ran hot, it ran cold, it ran rough, it staggered along on hot days and scared you half to death. Its wings flexed and twisted in a horrifying manner, it sank back to earth with a great sigh of relief. But it flew and it flew and it flew."

Top: This spiffy specimen rolled out in 1940 and was delivered to American Airlines. Today, 75,000 hours later, it's owned by Continental and wears ca.-1954 livery. Above: One of the first crop of -3s, in the days when people dressed up to fly.

LEFT: NASM (SI 72-6331); ABOVE: PHILIP MAKANNA/GHOSTS

Letters

B-29s, Continued

Your reply to Clint Royce's letter (June/July 2008) needs a little help from a B-29 and B-50 flight engineer. At the end of World War II, B-29 production was canceled. A single B-29A was fitted with Pratt & Whitney R-4360 engines and was distinguished by large cooling ducts and channels below the engine nacelles, plus a taller vertical stabilizer and rudder. This B-29A served as the prototype for an improved B-29 design that Boeing was trying to sell; it was designated the XB-44. In December 1945, the designation XB-44 was changed to B-50, and Congress approved production for a new strategic weapons system. It was the B-50 that had the R-4360s, as well as a taller vertical fin and rudder and other improvements.

Ted A. Bianchi
Cocoa Beach, Florida

Corrections

June/July 2008 "Detect and Direct": E-2s have not been in production longer than any other U.S. military airplane. The Lockheed C-130 has been in production longer (since 1955).

"Aircraft That Changed the World": The number of people who have flown on 747s was misreported as 3.5 million. The correct number is 3.5 billion.

WRITE TO US at Letters, *Air & Space/Smithsonian,* MRC 513, P.O. Box 37012, Washington, DC 20013. Please type or print clearly. You must include your full address and daytime phone number.

e-mail: *editors@si.edu*. All e-mails must include your full name, mailing address, and daytime phone number.

Air & Space is not responsible for the return of unsolicited materials. Never send unsolicited original photographs to the Letters department; send only copies.

All letters selected for publication are edited. We reserve the right to publish letters in the magazine, on our Web site (*www.airspacemag.com*), or both. We regret that we cannot respond to every letter.

The Running of the Nerds

JEREMY DAVIS

Kennedy Space Center engineers: Who's the fastest geek on the runway?

»» LIKE EVERYONE, Jeffrey Clark, an aerospace engineer at the Kennedy Space Center in Florida, puts his pants on one leg at a time. But one day last September, the self-proclaimed nerd pinned on a black bow tie and slid a white pocket protector into his shirt pocket.

Clark and co-nerds participate in the annual KSC Intercenter Run, held every fall at the Space Shuttle Landing Facility. The race, organized by the KSC Fitness Center and open to all spaceport employees, encourages workers to walk or run on the 15,000-foot shuttle runway. "From the start of the race, all you can see ahead of you is this endless track going up to the horizon," says Clark.

"The first year we went, we saw a bunch of people in blue Ground Ops shirts," Clark says, referring to workers who control the non-flight operations of shuttle launches. "We thought we'd like to identify the Solid Rocket Booster group in some sort of fun way. So the next year we all wore our Pi shirts," which were emblazoned with the first 4,493 digits of the famously unpatterned number.

For last year's run, inspiration came from Apollo-era forefathers. "Somewhere along the way, we thought, *Hey, let's all dress up as nerds!* I remember John Glenn wearing bow ties, so we thought it'd be cool to dress up in white shirts and black ties...horn-rimmed glasses and get cheap haircuts." Some wrapped the bridges of their coke-bottle eyeglasses with mounds of tape.

On race day, when the starting gun fired, dress pants and mismatched socks ran among the crowds of Spandex and running shoes. The engineers finished in modest time—25 or 30 minutes—despite some wardrobe difficulties. "The last half of the race was into the wind, and my tie kept blowing up into my face," Albert Oestriecher says. For some, the run provided time to reflect. Tom Singer, a stress analyst in the space shuttle program, says, "While I was running, I thought back to high school, and realized how surprising it is that I didn't get beat up more often by the cool kids."

JEREMY DAVIS

UPDATE

Downed

SHAUN LUNT, a pilot tutored by Loni Habersetzer in the art of landing on harsh terrain ("School of Hard Rocks," Apr./May 2008), died last June when the Piper Super Cub from which he was photographing a whale skeleton stalled, spun, and crashed in western Alaska. After Lunt went down, Habersetzer waited two hours for help to arrive. State troopers apparently were displeased that he then left. Habersetzer told the *Anchorage Daily News*, "After watching my friend burn for two hours, I just couldn't stay there anymore."

Pioneering Weirdness

ALTHOUGH PIONEER 10 has gone quiet, it's still speaking to some NASA researchers. Launched in 1972, Pioneer 10 became the first spacecraft to travel beyond Mars. Its primary mission was accomplished in December 1973 with a Jupiter flyby. For the next 30 years, Pioneer 10 kept humming along, reporting back on the outer solar system. The Deep Space Network last heard from the spacecraft in 2003.

While analyzing 11 years' worth of the craft's radio Doppler tracking data, Pioneer scientist John Anderson noticed a continuous slowing of the probe: a faint acceleration toward the sun, as if the craft, as it headed for the stars, were being tugged back by an invisible rubber band. Newtonian physics says it shouldn't be happening, but research mathematically projecting the spacecraft's course from past data shows that each year Pioneer 10 is about 3,000 miles short of where it should be.

Though the effect, dubbed the "Pioneer anomaly," is very weak, it is

ARTIST'S CONCEPTION BY DON DAVIS/NASA AMES

What is causing Pioneer 10 (above) and other deep-space probes to slow down on their journey beyond the solar system?

Last Call

LONGTIME FANS OF THE National Championship Air Races in Reno, Nevada, have lost their favorite watering hole. The Pylon Bar, which aviation enthusiast Barron Hilton created when he took over what became the Reno Hilton, closed last September, after a 13-year run.

In 1994, the Pylon Bar opened at the south end of the main floor, overlooking the Race and Sports Book, with its wall-to-wall bank of monitors and betting odds. Those entering the bar in its heyday, through the south entrance from the parking lot, stepped into an air race. A Midget Mustang hanging from the ceiling chased a pair of Cassutt racers around a checkerboard pylon.

KAREN KRISTIN

Patrons of the Pylon Bar, the after-hours hot spot during the Reno Air Races, bellied up to an air race panorama.

The showpiece was an eight- by 125-foot mural by artist Ron Gress that wrapped the vista of the Reno race course around the conversation area. Against the Sierra foothills, a Super Corsair led racers *Rare Bear*, *Strega*, and another P-51 into a turn past a pylon. In the periphery, Hilton's Staggerwing Beech banked while Wayne Hanley's Raven performed its airshow routine. Bob Hoover's P-51 pace plane held center stage.

The bar itself was festooned with checkerboards, flags, and models of famous racers, including Lefty Gardner's P-38, a Griffon-powered RB-51 Mustang, and an F4U Super Corsair. Near the north entrance was an array of plaques with the names and speeds of the winners of every final gold race.

What made the Pylon Bar a landmark were the pilots, crew, and fans who met there during race week every September. You'd find Bob Hoover talking with actor Cliff Robertson, or moonwalker Gene Cernan chatting with Barron Hilton himself. The guy standing next to you might have been an astronaut or a mechanic.

By the time the hotel was sold to air race fan Tom Schrade in 2006, the Pylon Bar was dead calm outside of race week. It's been replaced by Mustangs Dance Hall and Saloon, a country-western bar with a band and a small dance floor that is packed every weekend.

The Cassutts and Midget Mustang, along with the air race history inscribed in the winners plaques, have been moved to Reno's Stead Field, where the spirit of the Pylon Bar lives on in the Checkered Flag Club, a hangar just inside the pit gates reserved for special race guests.

LARRY LOWE

indisputable, and also occurred with Pioneer 11, which was launched a year later, in 1973. Anderson and colleagues considered a variety of explanations, from a leaking maneuvering thruster to dark matter pulling the craft off course or even the manifestation of a new theory of gravitation, but all were ruled out.

Then Slava Turyshev, a researcher at California's Jet Propulsion Laboratory, found boxes of Pioneer data tapes under a staircase, slated for disposal at NASA's Ames Research Center, Pioneer's former headquarters. The tapes were encoded in obsolete formats, but Turyshev managed to wrangle funding from the Planetary Society and JPL to translate the data into readable form. He and other investigators are using the data to construct computer simulations of the Pioneers' trips to tease out further clues.

Turyshev told an April 2008 meeting of the American Physical Society that one part of the answer seems to involve different parts of the spinning spacecraft radiating different amounts of heat, but he admits that the explanation does not account for the entire effect. He's hoping that the Pioneer tapes will enable accurate modeling of the behavior of a 40-year-old spacecraft that is now billions of miles from Earth. The puzzle has taken on added importance now that several other deep-space probes are behaving similarly.

MARK WOLVERTON

>>> Air&Space Interview <<<

Brigadier General Brooks Bash

U.S. AIR FORCE BRIGADIER GENERAL BROOKS BASH, COMMANDER, COALITION AIR FORCE TRANSITION TEAM, BAGHDAD, IRAQ

A COMMAND PILOT with more than 6,300 hours in a variety of mobility aircraft, Brooks Bash was named in March to head the 350-member transition team that is helping Iraq rebuild its air force. Earlier in his Air Force career, Bash served as deputy executive secretary for the National Security Council under the Clinton and Bush administrations.

What is the threat that Iraq needs an air force to counter?

Brooks Bash (center) oversees the training of Iraqi pilots and ground crew.

The current one is the counter-insurgency fight. The Iraqi air force is doing several things. Airlift and battlefield mobility, using their helicopters and light aircraft to move troops around in a tactical manner. Med-evac and casualty evacuation. They also do VIP support, flying the prime minister or the minister of defense. Future capabilities they'll be working for is air-to-ground attack capability, which the coalition is providing now. A little over a year ago, the Iraqi air force was like a flying club. They flew about 30 sorties a week, with no command and control. Today, they have an air operations center, 73 aircraft, and in April they set a record of 383 sorties in one week.

What's the structure of their fighter pilot force?

They used to have the largest air force in the Middle East, 500-plus aircraft. They flew MiG-25s, Su-27s, some of the older MiG-21s, Mi-17 helicopters. And some of those pilots have come back into the air force. Today you have a pilot force with more 50 percent between the age of 42 and 50, and those pilots have flown jets before. But they currently do not have the command-and-control capacity to have an effective air defense.... Their command-and-control system is just cell phones and a few radios, but that's what we're helping them build over the next couple years.

One of the pilots who soloed two weeks ago had never driven a car in his life. He did just fine. These young guys get in the simulator and spend time flying it around, and they're becoming better instrument pilots than the 45-year-olds.

Will Iraq put weapons on either the King Airs or the Cessna 208s it has ordered?

Not the current Cessna 208s. Starting in December, we will receive the first armed Cessna Caravan with the capability to fire an AGM-114 Hellfire missile. That will go on three Cessna 208s delivered in December, and then on two more [delivered] early next year. That'll give them their first true air-to-ground capability.

What's the long-term plan?

The idea is that in 2020 they would have an air force of 579 aircraft with capabilities that would provide for the air sovereignty of Iraq. You'd have trainers, some aircraft for battlefield mobility, special operations rotary-wing, armed reconnaissance rotary-wing, light and medium transports, ground-attack aircraft, some with intelligence, surveillance, and reconnaissance capability, some advanced jet trainers. And then eventually they'd move into the intercept, air-to-air [combat] jet.

CAPT. MARC SNODDY/USAF

ANYTHING'S POSSIBLE

TORGOEN
SWISS

PROFESSIONAL PILOT WATCHES

Quartz Precison Swiss Movement
Sapphire Scratch Resistant Crystal
Surgical Grade Solid Stainless Steel

Available at fine jewelry stores

www.torgoen.com

Beijing Airport Is Really Glad to See You

»» "BE NICE," the sign read. Johnny, the guide leading the group of Unisys executives that includes me as a reporter, explains that Beijingers haven't been known for congeniality. Now, all of China, but especially Beijing, is putting its best face forward for an expected two million Olympic visitors in August. The Games, Johnny says, are the government's chance to show that China is ready to take its place among the leading nations of the world. But first, he says, everyone needs to learn to be gracious hosts.

China has made a good start with its newly opened Terminal 3 at the once-dreary Beijing Capital International Airport. "From the air, it's shaped like a dragon," Johnny says. The building boasts more than 243 acres of floor space, and for anyone who ever flew into the shabby, cramped, retail-poor terminal of 10 years ago, the difference is miraculous.

Before T3 opened last March, the airport could handle about 35 million passengers annually; last year, close to 50 million crushed into the tiny spaces. The new T3 can accommodate 76 million passengers, the number projected to be using it by 2015, and 580,000 takeoffs and landings per year, or 124 an hour. (Busy O'Hare in Chicago ran at a 76-per-hour pace in April.)

The Olympics will test its peak capabilities: 2008 passenger traffic is expected to hit 64 million, and authorities plan to limit takeoffs and landings to 1,350 a day to minimize the notorious Beijing delays.

British superstar architect Norman Foster led the project to get T3 up in just four years and for $3.5 billion. At that speed, you might expect functional, utilitarian, and not much else. But the terminal is beautiful and relaxing, and moving through it is intuitive. The first thing an arriving traveler notices is the quiet: no blaring televisions, and only the occasional public address announcement. There's natural light and ultra-modern clean lines that incorporate traditional Chinese decor: Potted plants, medieval gardens, traditional copper cauldrons, and dragon carvings abound. So do Starbucks, Burger Kings, and Pizza Huts, but at least they're unobtrusive, and many travelers consider them amenities.

Sury Chavali, a partner in Unisys Asia-Pacific Airports Practice, which designed and deployed the systems running the airport, pointed out some differences from other airports. "Look at the floor," he said. "The culture here is to look down at where you're going, so there are directional signs on the floor." You can connect to Moscow, London, and Washington, D.C., from here, and you can reach Auckland on Air New Zealand or Irkutsk, Siberia, on S7 Airlines.

When departing, I noticed a Chinese sign showing acceptably tiny toiletries in clear plastic carry-on bags. Confident that as a seasoned traveler I knew the ropes, I happily diverted, when asked, to the U.S.-only screening line. There, the uniformed teenagers told me that I couldn't carry on any liquids or gels, even in amounts less than three ounces. "Why?" I asked. "It's a special rule for going to the United States." With a white-gloved hand and a big smile, a screener tossed my toiletries into a trash can. But he was really nice about it.

JIM MATHEWS

RON KUHLMANN /UNISYS

JIM MATHEWS

Beijing 2008

Fliers alighting at Beijing Airport's new Terminal 3 will be greeted by innovative architecture, a welcome reduction in public-address announcements, and gentle reminders to native Beijingers to make the city a rudeness-free zone for the upcoming Olympics.

In all my years as a GIA certified jeweler, I have never seen a magnificently large ruby at such an outstanding price. The Oval Ruby Collection is without a doubt one of the best jewelry offerings I've seen in years.
— James T. Fent,
Stauer GIA
Certified Gemologist

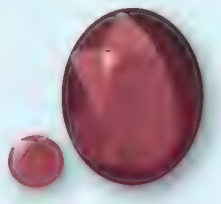
Huge Ruby Found on Bali—Is It Yours?

Paradise is reflected in this magnificent 22½ carat ruby...but the price is the most heavenly.

On the tropical island of Bali, the air is filled with ancient mystery and perpetual festivity. Who would have thought that our deep sea diving trip to this romantic paradise would lead us to a treasure of giant deep red rubies. This beautiful isle is so vivid and untouched it has become the spiritual inspiration for many an artist. Bali has gardens tripping down hillsides like giant steps, volcanoes soaring up through the clouds, long white sandy beaches, and friendly artisans who have a long history of masterful jewelry designs.

We stumbled upon a cache of giant natural rubies at a local artisan's workshop. He brought these exotic Burmese Rubies to Bali and now we have brought them home to you. Our necklace showcases a genuine **22½ carat** facet cut ruby set in a frame of .925 sterling silver in the Balinese style. *That's right—22½ carats!*

The ruby, raised above the hand-crafted Balinese silver detailing is surrounded by a bezel of sterling silver and then wrapped with a twisted rope. The Oval Ruby Pendant measures approximately 1¼" by 1½." This exotic pendant suspends from an 21" silver snake chain and secures with an spring ring clasp. Drape this pendant around your neck for a bold luxurious look. And, since rubies are rarer than diamonds, we hope your rings don't get jealous. Most likely, this will be the largest precious gemstone that you will ever own.



Compare the size of a 1 carat ruby to our 22.5 carat Oval Ruby.

The real surprise is that you probably expect this stone to sell for 1,000.00s of dollars. But our Stauer adventurers will go to the ends of the earth to find smart luxuries for you at truly surprising prices. And of course, if you are not thrilled with this find, send it back for a full refund of the purchase price within 30 days. As you can understand, this is an extremely limited offer. With rare rubies of this outstanding size and shape, we only currently have less than 490 rubies and may not ever be able to replace them again.

JEWELRY SPECS:
- 22.5 ctw oval facet cut ruby
- Pendant is 1 1/2" x 1 1/4" / weight is 1/2 oz.
- 18" sterling silver chain with 2" extender (optional)
- Stone color enhanced. Individual color may vary.

Sterling Silver Oval Ruby Collection

Pendant Necklace (22½ ctw) MSRP ~~$1,500~~
Your price **$125** +s&h

Bracelet (55 ctw) MSRP ~~$3,000~~
Your price **$295** +s&h

Earrings (15 ctw) MSRP ~~$2,000~~
Your price **$195** +s&h

Call now to take advantage of this limited offer.

1-800-386-5195

Promotional Code ORN131-02
Please mention this code when you call.

Stauer
14101 Southcross Drive W.,
Dept. ORN131-02
Burnsville, Minnesota 55337
www.stauer.com

Smart Luxuries—Surprising Prices

Mail Call

THE LETTERS COME IN by the thousands. Some ramble for several pages, others are succinct. A few are handwritten—occasionally scrawled, usually neatly printed—

Incoming correspondence is "triaged," says volunteer Guy Halford-MacLeod, who tracked down the 1963 Ozark Airline timetable to answer a recent query.

although the majority are typed or sent electronically. But they all want the same thing: information.

Dear Sirs,

On May 22, 1963, my family flew on a commercial flight from Joplin, Missouri, to Chicago, Illinois, with stops at Springfield MO, St. Louis MO, and Springfield IL. Is there any way that you can find out the airline on which we flew, the type of aircraft on which we flew, our departure time in Joplin, and our arrival time in Chicago?

"At first I thought, '*Yeah, right,*'" says Brian Nicklas, who has worked in the National Air and Space Museum's archives division for 20 years. "But then I realized that our volunteer Guy Halford-MacLeod would be able to answer it. Guy knows timetables and such, and he sent the gentleman a marvelous response."

"It was nothing," says Halford-MacLeod. "In the 1960s, airlines were tightly regulated, and only one airline would have flown the route from Joplin, Missouri, to Chicago. It didn't take very long to establish that the airline in question was Ozark, an airline that has long since disappeared." (See *ww.airspacemag.com/flight-today/grown.html.*)

With 15 permanent staff members and eight part-time volunteers, the archives handles more than 3,360 such queries each year. While the letters are enough to keep a task force busy, the staff also preserves the collections and works with donors to acquire items, frequently going on site to collect materials. (They've dug through the contents of attics, roamed dusty basements, and liberated knee-deep stacks of documents.) And while the bulk of the archives' collections is stored in a metal, no-frills building in Suitland, Maryland, the center of reference operations is in the Museum on the National Mall.

"Just because we won the war doesn't mean we have the blueprints."

–BRIAN NICKLAS, ARCHIVES DIVISION, NATIONAL AIR AND SPACE MUSEUM

The queries are as varied as the archives' content. Hobbyists frequently ask for technical and scale drawings, which have been donated to the Museum over the decades by manufacturers, the armed services, and individual illustrators.

Researchers like to peruse the archives' voluminous holdings, which include everything from Operation Paperclip correspondence (the 1945 U.S. effort to identify and evacuate German scientists and engineers ahead of the advancing Soviet army) to NASA pre- and post-launch mission reports for Mercury, Gemini, and Apollo flights to the 1937 logbook of U.S. fighter ace Gregory "Pappy" Boyington, later the commander of the famous U.S. Marine Corps "Black Sheep" squadron.

"The archives is committed to helping anyone and everyone," says supervisory archivist Marilyn Graskowiak. "If you are a modeler or the Imperial War Museum, we'll treat you the same way."

Although people have always been able to get answers to their aeronautical queries, there hasn't always been a place for researchers to visit. The collections were scattered throughout the Institution archives, in off-site storage, and in the hands of various curators. But by the mid-1980s, the archival collections had been gathered into the care of a single division, provided with a sunny room on the Museum's third floor.

We need an image of a pilot, or a pilot-like man. Might you have any photographs?

Indeed they do. The collections include nearly two million photographs, 700,000 feet of motion picture film, and two million

ERIC LONG (2)

technical drawings. The data spans the history of flight from ancient times to the present day, with an emphasis on the technical aspects of air- and spacecraft.

I seek all information relevant to the Curtiss P-40 used by the French forces between November 1942 and 1948.

There are certain queries the archives can't answer. "We're not the FAA, we can't certify your aircraft," explains Nicklas. And concerning the overwhelming number of requests for Japanese and German aircraft specifications, Nicklas sighs, "Just because we won the war doesn't mean we have the blueprints."

Regarding the Spirit of St. Louis: Does the inside of the starboard side cowling bear the names of the Ryan Monoplane Company workers that built the Spirit of St. Louis, including a paw print of the dog that lived at the factory?

With an annual budget of $14,000, the archives isn't a money-making project: "What little we charge goes to buy proper conservation supplies," says Graskowiak. Each time someone requests a duplicate of a microfilm reel, for instance, the $30 processing fee helps to offset the cost of remastering unstable micofilm onto stable polyester film stock.

What's the origin of the term "touch-and-go" as used in aircraft landing and takeoff practice?

The archives has its regulars. "Mr. Dumas has been writing to us, from France, every month—for years now," says Nicklas. "We sometimes wonder what he's doing. He might be starting his own museum."

It's not such a far-fetched idea. Each written response to a query is a small gem, highlighting the knowledge of the archivists and volunteers who staff the division.

REBECCA MAKSEL

To read a selection of letters sent to the archives and the archivists' detailed replies (including the answers to the questions in this article), and to learn more about volunteering at the archives, visit our Web site at www.airspacemag.com.

Visitor Information

Star Party Join Museum staff astronomer Sean O'Brien on two Saturdays, August 23 (7:45 p.m. to 11 p.m.), and September 27 (7 p.m. to 11 p.m.), in observing celestial objects in skies unpolluted by city lights. Sky Meadows State Park, Virginia. Parking fee: $4 per car. Park phone: (540) 592-3556.

What's Up Receive regular updates on Museum events, read about artifacts, get detailed (and behind-the-scenes) exhibition information, and receive calendar listings by subscribing to the National Air and Space Museum's free monthly e-newsletter, *What's Up*. Sign up at *www.nasm.si.edu*.

National Air and Space Society Members of the National Air and Space Society are charitable donors who support the mission and programs of the National Air and Space Museum. Society membership offers advance access, invitations to special events in the Museum, and other benefits. Like *Air & Space* associate members, National Air and Space Society members receive *Air & Space* magazine and discounts. Unlike associate members, Society members make contributions that help fund the Museum's restoration, preservation, and education efforts. Both memberships support the Smithsonian Institution. For more information, visit *www.nasm.si.edu/membership*.

ARTIFACTS

Pfalz Memory

DESIGNED TO REPLACE the obsolete Albatros and Pfalz D.III scouts and the outclassed Fokker Dr.I triplane, the German-built Pfalz D.XII first appeared on the Western front in 1918. The all-wood biplane could dive faster than the Fokker D.VII, but it couldn't turn as well, leading one pilot to compare the Pfalz to "a clumsy cart-horse." By the time of the Armistice, nearly 800 aircraft had been delivered to frontline service; about 175 were turned over to the Allies after World War I. Of these, only four survive. Two were brought to the United States as part of war reparations, and were put to use in Hollywood films, including Howard Hughes' *Hell's Angels* and Howard Hawks' *Dawn Patrol*. The National Air and Space Museum acquired its Pfalz in 1951; in 1989 it was installed in the Legend, Memory, and the Great War in the Air exhibition and repainted as it appeared during its Hollywood heyday.

The Museum's Pfalz D.XII fighter logged more flying hours in Hollywood movies than in the war.

"I Have a Flameout"

IN THE U.S. AIR FORCE, learning to fly the high-altitude U-2C reconnaissance airplane was a rare experience. No two-place trainer existed for the U-2 student in the 1960s. With its spectacular 80-foot wingspan, removable outrigger "pogo" wheels under the wings, tandem main landing gear, wing skids at the wingtips, and a powerful Pratt & Whitney J75 jet engine in a relatively slim fuselage, the U-2 was a handful. And every flight was solo.

As a young Air Force captain at Davis-Monthan Air Force Base in Arizona in January 1967, I had made the first five qualification flights at low altitude, learning how to take off and land. Because control at low speed was marginal and landing required a full stall, all landings were assisted by another U-2 pilot driving a Chevrolet El Camino with a souped-up engine. The driver raced down the runway behind the landing airplane, radioing height information: "One foot...six inches...hold it off.... Good touchdown!"

On my sixth U-2 flight I had taken the airplane above 60,000 feet, wearing my skin-tight MA-1 partial-pressure suit, which was designed to keep me alive in case of a depressurization. Before descent and landing, the training called for an engine shutdown at high altitude, so the pilot would be familiar with depressurization, suit inflation, and sluggish flight controls. After restarting the engine at lower altitude, I returned home and landed uneventfully.

Six days later, on a February day in 1967, I climbed into the U-2 for my seventh training flight, a mission of four-plus hours involving celestial navigation and photo reconnaissance that would for the first time take me away from the area around Davis-Monthan. The cockpit was so cramped I felt like I was putting the airplane on rather than getting into it. When everything was hooked up, I started the engine and taxied toward the active runway.

To the student pilot, a U-2 was a cross between an over-powered glider and a high-performance fighter.

LOCKHEED MARTIN

"Spicy 42, cleared for takeoff when ready. Winds 090, six knots."

"Roger 42."

I began the takeoff procedure: Roll onto the active runway and hold. Show the ejection seat pins to the driver of the chase vehicle (another U-2 pilot) to signify that I had armed the ejection system. Pump and hold the brakes. Throttle to 80 percent. Check all instruments. Tracker camera on. Release the brakes and push the throttle smoothly to the gate.

On takeoff, the acceleration was so powerful it was like being launched by a gigantic rubber band. The steep climbout and departure went fine. After reaching 60,000 feet, I got busy with the mission's activities.

About two hours later, I was cruising serenely, straight and level over the western states. I had just taken a final celestial shot of the sun. I had amassed a grand total of 15 hours in the U-2, and despite the constant attention the airplane required, I was finally able to gaze at the snowy white, unbroken deck of clouds below.

BANG! The airplane produced a violent, high-frequency vibration, with an immediate sensation of deceleration. On the cabin altimeter, the needle that indicated the atmospheric pressure in the cockpit spun rapidly toward the same altitude as the airplane. Simultaneously with the engine flameout, the capstans of my partial-pressure suit inflated, squeezing my torso in their grip and forcing me into a stiff, hunchback posture.

My first conscious thought was to maintain control of the aircraft. Keeping the wings level, I eased the nose down to avoid a stall and settled into the best glide speed. I pulled out a mission planning chart and saw that the nearest suitable emergency airport was Kingsley Field at Klamath Falls, Oregon, 122 miles to the west.

As I eased the airplane into a left turn, I changed the battery switch position to conserve electrical energy

Official New York Mint Release:

25 Years of U.S. Mint Sets

In One Fantastic Limited-Edition Collection!

Now you can get every year and every coin—including all the classic silver issues—for one low price!

Each year when the U.S. Mint strikes a small number of U.S. Mint Sets, collectors scramble to get their share of the limited edition. Now, we're making these sets available to you in this amazing 25-year collection—**over 250 coins in all!**

Mint Sets are the only way to get every annual U.S. coin in every denomination. Unlike the circulated coins that have jingled in your pockets, these Uncirculated beauties were packaged by the U.S. Mint especially for collectors. You'll get the LAST Franklin Half Dollar, the FIRST and ONLY silver Kennedy Half Dollars, the beloved Bicentennial coins, the FIRST Ike Dollars, the FIRST and COMPLETE Susan B. Anthony Dollar collection—plus special-release issues and much more—all for about $1.50 a coin!

Now you can order this complete 25-year U.S. Mint Set (1964 – 1990*) and save! Plus, for a limited time, you will also receive two FREE bonuses: the 1976 special Bicentennial 3-coin set and a beautiful hardcover book about U.S. Mint Sets by Bill Gale and Ron Guth, two nationally-recognized experts in the field of numismatics. Don't wait—call today to get in on this fantastic offer for **only $395!** (plus S&H)

1-800-642-9160

ext. 6214

New York Mint • Edina, MN

*U.S. Mint Sets were not issued in 1982 & 1983.

so I could keep the helmet faceplate defroster working, power the essential flight instruments, and ensure that I would have enough juice to lower the landing flaps.

"Seattle Center, Spicy 42, MAYDAY. I have a flameout. Heading for Kingsley. Will not transmit again to conserve electrical. Request vectors to keep Kingsley at my 12 o'clock, over."

"Ahh, roger, Spicy 42, Seattle Center. Kingsley Field current weather scattered clouds at 1,200 feet, 3,500-foot overcast, 15 miles visibility, winds variable, 260 degrees at 10 to 12 in snow showers, altimeter 29.94."

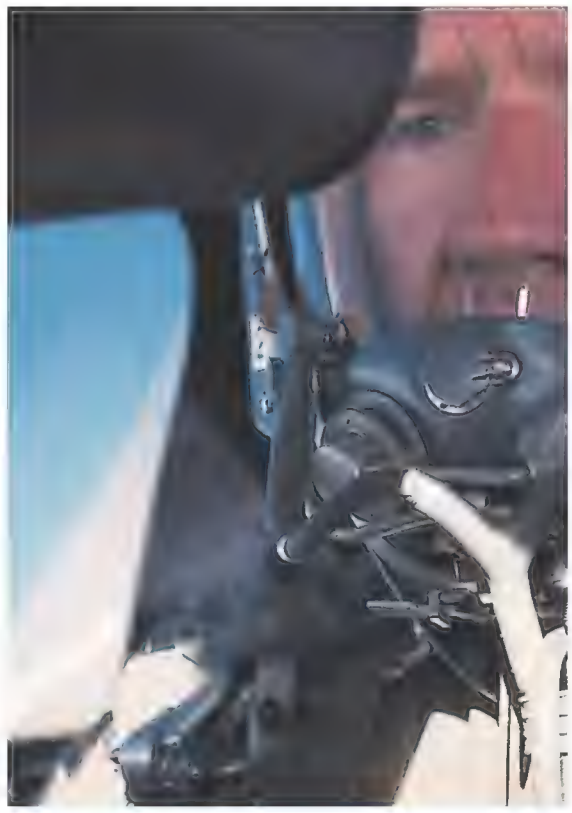
The situation presented three scenarios. The most attractive was that I would continue gliding toward Kingsley Field until reaching a lower altitude, where I would try to restart the engine. If I got a relight, I would return to home base.

Scenario two: Despite the clouds, I would eventually catch sight of the airfield early enough to make an emergency flameout landing. The marginal weather and the fact that I would be landing the U-2 for the first time with no chase vehicle to call out my height above the runway—customary for all U-2 pilots, not just beginners like me—made this scenario less attractive.

The least attractive possibility was simply to eject and hope I could survive the winter conditions. Fearing there might be high terrain around the airfield, I decided I would eject only if I hadn't caught sight of the field by the time the altimeter read 5,100 feet, or 1,000 feet above Kingsley Field.

As I descended toward the solid white undercast, the frigid temperatures penetrated the cockpit, numbing my hands through the pressure gloves, and formed a light frost on the metal surfaces and the inside of the canopy. Confident that Kingsley was within gliding range, I extended the landing gear to slightly increase the rate of descent. As I encountered the higher pressure of the lower altitude, the pressure suit automatically relaxed, making movement easier.

Passing through 18,000 feet, I entered the dim light of the overcast and had an unsettling sensation of time acceleration. I was descending into a wintry, hostile environment, and shortly, I'd be either landing or ejecting. The frost on the inside of the canopy now seriously impaired my ability to see out, so I used a plastic protractor-like navigation aid called a Weems Plotter as a scraper. I scratched at the frost and searched below the airplane, but saw nothing except solid clouds. It was like descending into a gigantic glass of milk. Finding the field



COURTESY OF RICHARD G. WOODHULL, JR

I saw, at the dark bottom of a break in the clouds, a line of five blue lights.

would be a miracle.

Seattle Center (breaking up): "Spicy...2.... five miles east of Kingsley.... still.... your 12 o'clock..."

I replied that I would attempt a flameout landing at Kingsley and asked for more position advisories, but I received no further transmissions.

Conditions improved slightly between cloud decks at 12,000 feet. I removed and stowed the helmet faceplate, always a joyful moment in a U-2 flight. Because the faceplate might not reseal properly, opening it above 10,000 feet was prohibited. After six or seven hours of not being able to scratch your nose or rub your eyes, the pleasure of doing so was indescribable.

Then, a miracle. For a fleeting moment, as I passed through 11,000 feet, scraping frost and peering down, I saw, at the dark bottom of a narrow break in the clouds, a line of five blue lights. It could mean only one thing: taxiway lights at Kingsley Field.

I immediately extended the landing flaps, slowed to the proper flameout-pattern speed, and turned to the Kingsley runway heading. I held that heading for just a moment, then started a slow left turn.

The idea of a flameout pattern is to lose half the altitude over the field during the first 180 degrees of turn, and lose the remaining altitude while completing the second 180 degrees and arriving at the runway heading again. During the descending turn in the clouds, I caught glimpses of the airfield complex, but not the runway. Then, after 270 degrees of turn, I broke out into the clear. I looked ahead and to the left, where I hoped to see the runway, but saw only trees and farms.

Then I looked farther back to the left. There it was. The approach end of the runway was fairly close, but I had overshot badly to the right.

I banked steeply left while diving slightly to maintain airspeed and avoid a stall. There was a crosswind from the left as I rolled out toward Runway 32. I crossed the threshold at five or 10 feet, but with excess airspeed. Then, more good luck. The large main landing gear made almost-imperceptible contact with the runway, providing the height-above-the-runway information that I usually received from a chase vehicle. I was able to make a normal full-stall landing. The airplane rolled to a stop on the centerline with its left wingtip skid touching the runway.

With the adrenaline still flowing, I gave hearty thanks to my instructors and their excellent training. By making a dead-stick landing, I had just qualified for the 349th Strategic Reconnaissance Squadron's exclusive Silent Birdman club.

RICHARD G. WOODHULL JR.

How Has Christianity Changed over 2,000 Years?

Follow the Story of *Lost Christianities*, an Intriguing, 24-lecture Series in Audio or DVD

In the first centuries after Christ, there was no New Testament. However, books of Gospels, Acts, Epistles, and Apocalypses were widely read, and were fervently followed by groups of early Christians. But they would not be among the books that formed the New Testament.

From the many different scriptures then available, Christians held beliefs that today would be considered bizarre: that there were two, 12, or as many as 30 gods; that a malicious deity, rather than one true God, created the world; that Christ's death and resurrection had nothing to do with salvation—others insisted that Christ never really died at all.

What did these "other" scriptures say? Do they exist today? How could such outlandish ideas ever be considered Christian? If such beliefs were once common, why do they no longer exist? These are just a few of the many provocative questions that arise in **Lost Christianities: Christian Scriptures and the Battles over Authentication**.

A Good Mystery Story

This 24-lecture series is a richly rewarding learning opportunity for anyone interested in religion, history, or a good mystery story. Professor Bart D. Ehrman lends his expert guidance as you follow scholars' efforts to recover knowledge of early Christian groups who lost the struggle for converts and subsequently disappeared.

A major theme of this course is the struggle for orthodoxy—or right belief—among the various early Christian groups. You will witness the process by which certain Christian beliefs gained legitimacy, while others were relegated to the status of footnotes to history.

You will see how Christianity developed through its early and lost writings. The struggle for orthodoxy can be seen in both the New Testament and in central Christian creeds. You will explore the development of the New Testament into an approved canon of scripture.

How did the process of forming the orthodox canon take place? Who decided which books should be included? On what grounds? If so many scriptures existed, how do we know that those who selected the final books got it right? If many of these writings were forgeries, how can we be sure that forgeries weren't included in the New Testament?

In these lectures you will also hear about a remarkable archaeological event: the discovery in 1945 of a treasure trove of missing Gnostic scriptures at Nag Hammadi, an Egyptian village near the city of Luxor.

Consisting of 13 leather-bound volumes unearthed in an ancient grave by Bedouin camel drivers (the full story, which you will hear, resembles the plot of a bestselling adventure novel), the Nag Hammadi Library was a watershed event in the search for lost Christianities.

About Your Professor

Dr. Bart D. Ehrman is the James A. Gray Professor and Chair of the Department of Religious Studies at The University of North Carolina at Chapel Hill. He received his Masters of Divinity and Ph.D. from Princeton Theological Seminary. He has won several teaching awards, including the Students' Undergraduate Teaching Award and the Bowman and Gordon Gray Award for Excellence in Teaching. Professor Ehrman has written or edited more than 15 books, including *The New York Times* best-seller, *Misquoting Jesus,* and *Jesus: Apocalyptic Prophet of the New Millennium*.

About The Teaching Company

We review hundreds of top-rated professors from America's best colleges and universities each year. From this extraordinary group we choose only those rated highest by panels of our customers. Fewer than 10% of these world-class scholar-teachers are selected to make The Great Courses®.

We've been doing this since 1990, producing more than 3,000 hours of material in modern and ancient history, philosophy, literature, fine arts, the sciences, and mathematics for intelligent, engaged, adult lifelong learners. If a course is ever less than completely satisfying, you may exchange it for another, or we will refund your money promptly.

Lecture Titles

1. The Diversity of Early Christianity
2. Christians Who Would Be Jews
3. Christians Who Refuse To Be Jews
4. Early Gnostic Christianity—Our Sources
5. Early Christian Gnosticism—An Overview
6. The Gnostic Gospel of Truth
7. Gnostics Explain Themselves
8. The Coptic Gospel of Thomas
9. Thomas' Gnostic Teachings
10. Infancy Gospels
11. The Gospel of Peter
12. The Secret Gospel of Mark
13. The Acts of John
14. The Acts of Thomas
15. The Acts of Paul and Thecla
16. Forgeries in the Name of Paul
17. The Epistle of Barnabas
18. The Apocalypse of Peter
19. The Rise of Early Christian Orthodoxy
20. Beginnings of the Canon
21. Formation of the New Testament Canon
22. Interpretation of Scripture
23. Orthodox Corruption of Scripture
24. Early Christian Creeds

THE TEACHING COMPANY®
The Joy of Lifelong Learning Every Day™
GREAT PROFESSORS, GREAT COURSES, GREAT VALUE GUARANTEED.™

About Our Sale Price Policy

Why is the sale price for this course so much lower than its standard price? Every course we make goes on sale at least once a year. Producing large quantities of only the sale courses keeps costs down and allows us to pass the savings on to you. This also enables us to fill your order immediately: 99% of all orders placed by 2 pm eastern time ship that same day. Order before October 7, 2008, to receive these savings.

SAVE UP TO $185!
OFFER GOOD UNTIL OCTOBER 7, 2008

1-800-TEACH-12 (1-800-832-2412)
Fax: 703-378-3819

Special offer is available online at
www.TEACH12.com/4sas

The Great Courses
THE TEACHING COMPANY
4151 Lafayette Center Drive, Suite 100
Chantilly, VA 20151-1232

Priority Code 29046

Please send me **Lost Christianities: Christian Scriptures and the Battles over Authentication**, which consists of twenty-four 30-minute lectures plus Course Guidebooks.

☐ **DVD $69.95** (std. price $254.95) **SAVE $185!**
plus $10 shipping, processing, and Lifetime Satisfaction Guarantee

☐ **Audio CD $49.95** (std. price $179.95) **SAVE $130!**
plus $10 shipping, processing, and Lifetime Satisfaction Guarantee

☐ **Audiotape $34.95** (std. price $129.95) **SAVE $95!**
plus $10 shipping, processing, and Lifetime Satisfaction Guarantee

☐ **Check or Money Order Enclosed**

* Non-U.S. Orders: Additional shipping charges apply.
For more details, call us or visit the FAQ page on our website.

** Virginia residents please add 5% sales tax.

Charge my credit card:

☐ VISA ☐ ☐ ☐

ACCOUNT NUMBER EXP. DATE

SIGNATURE

NAME (PLEASE PRINT)

MAILING ADDRESS

CITY/STATE/ZIP

PHONE *(If we have questions regarding your order—required for international orders)*

☐ **FREE CATALOG.** Please send me a free copy of your current catalog (no purchase necessary).

Special offer is available online at www.TEACH12.com/4sas
Offer Good Through: October 7, 2008

Zeppo's Gizmo

"...I tell you how we fly to America. The first time we started, we get halfway across when we run out of gasoline and we gotta go back."
– CHICO MARX, *A NIGHT AT THE OPERA* (1935)

Aside from punchlines, what did the Marx Brothers have to do with aviation? Consider Marman Products, an aerospace manufacturing firm founded by Herbert (Zeppo) Marx in 1941. You may not remember Zeppo; he appeared in only five of the brothers' feature films. Yet perhaps befitting its origins, his story of aviation success plays like a Marx Brothers movie.

Scene 1: Zeppo, who was handy with tools, meets an aircraft executive at the racetrack. "We're very shy of machine shops and machinists," the Douglas Aircraft man confides, "and I hear you have your own shop." Before you know it, Zeppo is machining parts for DC-3s at his lathe in the family garage. So begins Marman Products. Inventory (in cardboard boxes) is piled on the dining room table. Work commences at one in the morning, after Zeppo's show business duties.

Scene 2: As Zeppo's business grows, he meets a starving inventor ("A terrible looking man; holes in his shoes!" Marx recalled in *Hello, I Must Be Going* by Charlotte Chandler.) The innovator has a new kind of aircraft clamp he wants someone to market. Not too different from those screw-on clamps you use to repair a garden hose, but with several improvements. Turns out the gizmos are perfect for joining flexible aircraft fuel lines. They stand high pressure so well that Marman band clamps are used to help make turbocharged wartime aero engines possible. They also secure air intakes, hydraulic hoses, and oxygen supplies aboard Boeing B-29 bombers and other aircraft. Extra-large clamps hold cargo.

To keep up with demand, Zeppo's machine shop expands out of the garage and into two large factories, employing more than 500. The production line employs prop men from RKO's special effects department and big-band musicians between gigs.

Clamps inspired by Zeppo's original find work everywhere in aviation, providing leakproof fuel, hydraulic, and other joinery; square versions fasten gauges to instrument panels.

Scene 3: The Marx Brothers in space? When John Glenn rode into orbit aboard *Friendship 7* in 1962, a six-foot-diameter Marman-type clamp released the capsule from the Atlas rocket, with explosive bolts blasting open the clamp. (Harpo would have liked that.) Today, the use of Zeppo's fastening techniques at the separation plane of a spacecraft (the point where a satellite disconnects from its booster) is the standard method for deploying payloads from the space shuttle's cargo bay. In space, the clamp works both when it holds and when it doesn't. Or when it holds just a little. Like during Cassini's flybys past Saturn, which began in 2004. The orbiter's plasma spectrometer must turn to measure the planet's magnetic field; this was enabled by a Zeppo-inspired clamp that squeezes to hold the instrument fixed, then loosens to permit rotation.

When the European Space Agency's four Cluster satellites (which study Earth's magnetosphere), unofficially dubbed Groucho, Harpo, Chico, and Zeppo (and a spare named for Gummo), were launched in 2000, ground controllers were doubtless unaware how much their mission depended on the work of a real Marx Brother. To fit inside their launch vehicle, each identical Cluster satellite mated to its brother (an aerospace first) with a Marman-type closure. Once in space these fittings burst, releasing the orbiting formation of four to whirl around Earth.

NICK D'ALTO

DAVID CLARK

We Apologize That It Loses 1 Second Every 20 Million Years

First Super Light Titanium Timepiece Under $200 With Precision to 1 Billionth of a Second.

The U.S. government has engineered the most ingenious, most accurate clock in the world: the F-1 U.S. Atomic Clock in Boulder, Colorado. Our extraordinary new Stauer Titanium Atomic Watch utilizes the transmissions directly from that remarkable cesium fission atomic clock to report the most precise time. This scientifically advanced timepiece will gain or lose only one second over a 20 million-year period. It is that accurate! This perfectly tuned technological invention with the super light strength of titanium is now available for UNDER $200.

Super Light Titanium has two big advantages over steel. One is corrosion resistance and the other is that titanium has the highest strength-to-weight ratio of any metal, which means that titanium is approximately 45% lighter than steel. But every other titanium watch that we can find is priced at over $400, and none of those are nearly as accurate as our atomic movement. Stauer has decided to bring these resources together in a timepiece that has the most accurate movement available today. You'll never have to set this watch. Just push one of the buttons and you are synchronized with the atomic clock in Colorado, and the hands of the watch move to the exact time position. The sleek black textured dial has luminous hands and markers plus the timepiece is water resistant to 3 ATM.

A Titanium-clad offer. This Titanium Atomic Watch exceeds the accuracy of any Swiss luxury automatic so you can be more punctual and keep most of your money in your wallet, not on your wrist. Look at your watch and we guarantee that the time is incorrect, unless you are wearing the advanced atomic technology.

The Stauer Titanium Atomic Watch is not available in stores and it comes with our 30 day money-back guarantee. If you're not completely satisfied with the accuracy, simply return the watch for the full purchase price.

M.S.R.P. $595. Now $195

Not Available in Stores

Stauer Titanium Atomic Watch $195 +S&H or
4 credit card payments of $48.75 +S&H

Call Toll-Free now to take advantage of this limited offer.

1-888-201-7141

Promotional Code TTA182-03
Please mention this code when you call.

To order by mail, please call for details.

Stauer
Heritage of Art & Science

14101 Southcross Drive W.,
Dept. TTA182-03
Burnsville, Minnesota 55337
www.stauer.com

Finding

FORTY YEARS LATER, WE'RE ABOUT TO SEE WHAT THE MOONWALKERS LEFT BEHIND. BY TONY REICHHARDT

THE FLAG IS PROBABLY GONE. Buzz Aldrin saw it knocked over by the rocket blast as he and Neil Armstrong left the moon 39 summers ago. Lying there in the lunar dust, unprotected from the sun's harsh ultraviolet rays, the flag's red and blue would have bleached white in no time. Over the years, the nylon would have turned brittle and disintegrated. Dennis Lacarrubba, whose New Jersey-based company, Annin, made the flag and sold it to NASA for $5.50 in 1969, considers what might happen to an ordinary nylon flag left outside for 39 years on Earth, let alone on the moon. He thinks for a few seconds. "I can't believe there would be anything left," he concludes. "I gotta be honest with you. It's gonna be ashes."

There are other signs of aging at Tranquillity Base. The shiny gold foil on the base of the lunar lander is shiny no more—it would have darkened and flaked away long ago. The once-white life support backpacks, tossed out unceremoniously after Armstrong and Aldrin made their brief spacewalks, have likely turned yellow. The TV camera, the seismometer, the discarded hammer—anything made of glass or metal—are probably okay. And the famous bootprints? They may still be as crisp as the day they were made. Or, they may have the thinnest coating of dust from small grains moving around continually on the lunar surface (see "Stronger than Dirt," Aug./Sept. 2006).

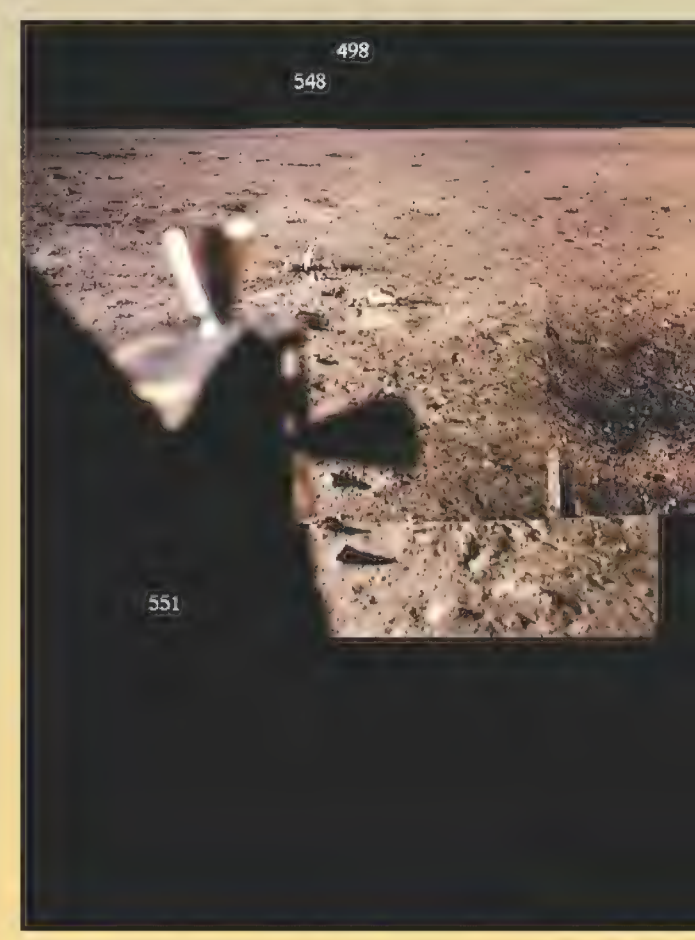
The truth is, no one knows exactly what the Apollo landing sites will look like after four decades. Nobody thought it would take us this long to go back.

And now we are.

New cameras in orbit around the moon have begun returning photos of sights unseen in a generation. Japan's Kaguya spacecraft, which arrived in lunar orbit in October, took a picture of the Apollo 15 landing site in February that clearly showed a tiny patch of white on the dark gray landscape—dust disturbed by Dave Scott and Jim Irwin's rocket engine as they touched down in Mare Imbrium in July 1971. They and other Apollo moonwalkers routinely photographed the white patches when they looked back at their landing sites from lunar orbit before returning home. Kaguya's best camera has a resolution, or ability to separate two objects, of 10 meters (33 feet)—just enough to make out the white patch of disturbed soil. The camera can't quite resolve the squat, 30-foot-wide base of the Apollo 15 lander sitting in the middle of that patch. But the Kaguya photo shows a dark feature that may be the lander's shadow.

Until Kaguya, there hadn't been a camera good enough to spot Apollo artifacts on the moon since the last astronauts left, in 1972. Neither the U.S. Clementine nor the European SMART-1 moon probes, launched in 1994 and 2003, respectively, had enough resolution. (In case you're wondering, even the best ground-based telescopes can't make out Apollo hardware on the moon. They have the resolution—some produce sharper images than the Hubble Space Telescope—but the objects left by the astronauts aren't bright enough to be seen.)

So it's a job for lunar orbiters. Next up is Chandrayaan, India's first planetary science spacecraft, which is due to arrive at



Apollo

the moon this fall with a camera twice as sharp as Kaguya's. That should be good enough to see more than smudges in the dirt, according to Mark Robinson, a planetary scientist at Arizona State University whose own high-resolution camera will fly on NASA's Lunar Reconnaissance Orbiter (LRO) in November. "I will be surprised if Chandrayaan can't detect the [lunar landers]," says Robinson. The bases of the landers, six of which are still on the moon, will be only about two picture elements, or pixels, across in the five-meter-resolution images—not enough for clear identification. But in photos taken at low sun angles, says Robinson, the landers' shadows should appear as dark streaks up to 10 pixels long. This technique has paid off in the past. Long before the first Apollo landing, scientists studying photos taken by the Lunar Orbiter 3 spacecraft noticed a shadow cast by the Surveyor 1 robot, which had landed on the moon eight months earlier.

If the Chandrayaan scientists are "really, really lucky," says Robinson, they might also detect the shadows of the lunar rovers, the two-man buggies that astronauts left at the Apollo 15, 16, and 17 sites. The 10-foot-long rovers would be less than a pixel in size, but their shad-

The shadow of their lander dominates a mosaic of the numbered photos Neil Armstrong and Buzz Aldrin took out their window before leaving the moon.

NASA/PANORAMA ASSEMBLED BY R. FARWELL FOR THE APOLLO LUNAR SURFACE JOURNAL

TO SEE SOME OF THE NEW PICTURES OF THE APOLLO LANDING SITES, GO TO WWW.AIRSPACEMAG.COM

ows could be as long as four or five pixels, says Robinson.

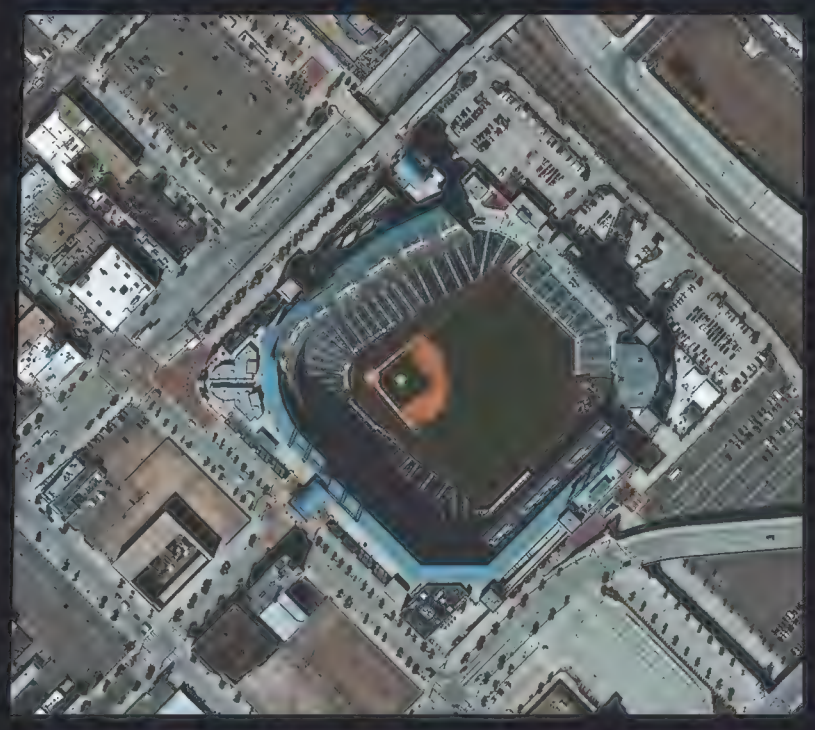
His own instrument on the LRO will do a thorough job of "revisiting" the Apollo sites, beginning in early 2009. The narrow-angle camera can resolve details about the size of a microwave oven. As the LRO spacecraft orbits from pole to pole and the moon turns slowly beneath it, it will eventually get a look at all six Apollo landing sites. The resulting pictures should clearly show the landers and the rovers, says Robinson. Even some of the larger experiment packages left behind by the moonwalkers might be identifiable from their shadows. The LRO images should also show rover tracks and the dark areas where the astronauts scuffed up the lunar soil. The new information can then be used to refine maps of the moonwalkers' historic traverses.

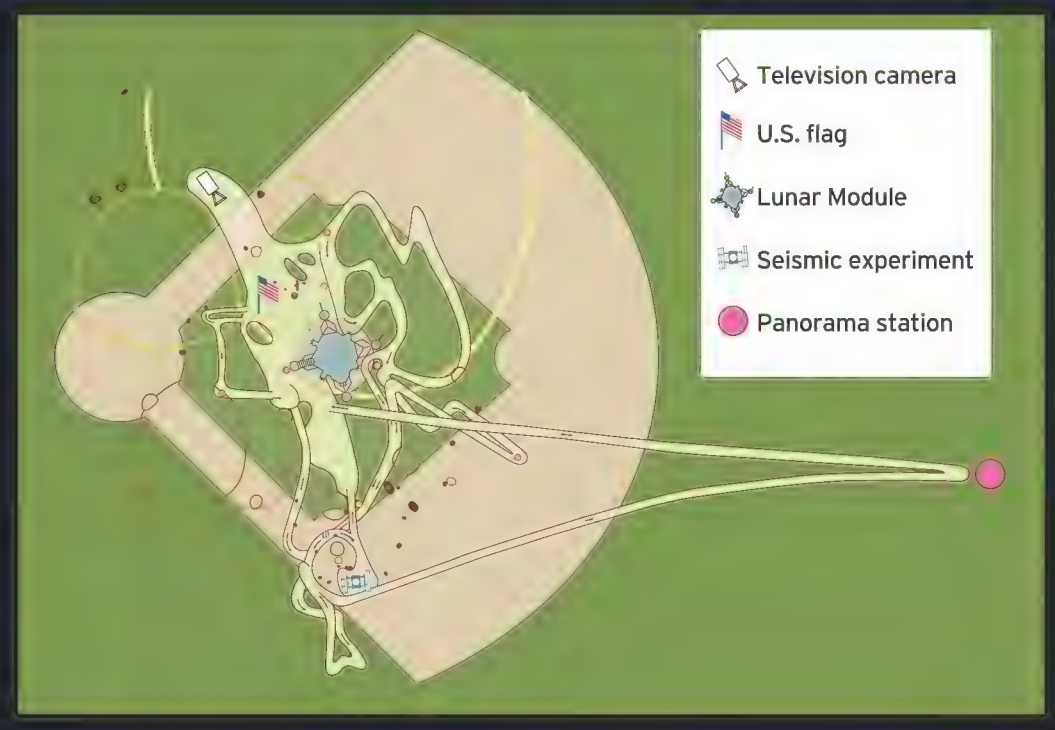
And that's just Apollo. Some of the most fascinating pictures the LRO takes will show obscure spacecraft that nobody's seen, or even thought much about, since they left Earth more than 40 years ago. Phil Stooke, a planetary geographer at the University of Western Ontario and author of *The International Atlas of Lunar Exploration*, has a list of targets he can't wait to see, including two Russian spacecraft—Luna 9, which in 1966 made the first soft landing on the moon, and Luna 17, which in 1970 delivered the first geological rover, Lunokhod 1. Neither spacecraft's location is precisely known, says Stooke. Nor are the exact locations of many of the craters made when orbiters and spent rocket stages crashed into the moon in the 1960s. Altogether, about 100 tons of junk is strewn across dozens of spots around the moon. Over the next two years, we'll rediscover much of it.

Of course, the LRO's mission is not finding old spacecraft. The orbiter is producing high-resolution maps for planning the next wave of lunar exploration. But since astronauts aren't expected to head moonward until 2020 at the earliest, the initial users of the maps are likely to be surface-exploring robots, and the first of those could arrive as early as next summer, in time for the 40th anniversary of Apollo 11. An intense contest is under way among several groups vying for the $30 million Google Lunar X Prize, which will go to the first privately funded team that lands a rover on the moon, drives it at least 500 meters (about a third of a mile), and returns video and still images to Earth.

Just as the first X Prize spurred aircraft designer Burt Rutan to build a one-man rocketplane that flew to the edge of space and back (see "Confessions of a Spaceship Pilot," June/July 2005), the Google prize is meant to encourage innovation in robotic exploration of the moon. So far, 13 teams have entered, from as far away as Romania and Malaysia.

The Rutan in this race is Carnegie Mellon University's Red Whittaker, one of the world's foremost roboticists. Whittaker-built rovers have explored volcanoes, deserts, and Antarctic ice fields. Last year one of his vehicles won the DARPA Urban Challenge, a road rally for autonomous robot cars, sponsored by the Defense Advanced Research Projects Agency. Whittaker's X Prize team, Astrobotic Technology, is loaded with experience, starting with project manager Tony Spear, the man who led the NASA mission that in 1996 landed the Sojourner rover on





LEFT: GEOEYE; RIGHT: ERIC JONES AND THOMAS SCHWAGMEIER, ALSJ

Apollo 11's moonwalkers stayed in an area about the size of a baseball infield (right); Armstrong's farthest foray was to take a panoramic photo of the site. The Lunar Reconnaissance Orbiter's 20-inch resolution will produce a view comparable to the aerial photo at left.

Mars. The University of Arizona's Lunar and Planetary Laboratory, currently operating the Phoenix spacecraft on Mars, is a partner. Astrobotic's president is David Gump, a space entrepreneur who in 1989 started a venture called LunaCorp, which also planned to drive a rover around the moon and sell the video. Whittaker was to have built the robot. Although LunaCorp folded in 2003, Gump is betting that it was mostly because the company was ahead of its time.

Not that Astrobotic's proposed "Tranquillity Trek" to the Apollo 11 site will be a cakewalk. For one thing, says Gump, the mission will cost about $100 million—far more than Google is paying in prize money. While he looks for financial backers, the technical team is working feverishly, trying to hold on to the possibility of a launch next year. Astrobotic claims that once it raises the money, it can be on the moon within 18 months.

After landing, Astrobotic's rover will have just 14 days—a lunar day—to reach the Apollo 11 site and take pictures. Equipping the robot to withstand the frigid, two-week lunar night would have complicated the engineering and driven up the cost. So this will be a short, focused sprint to Tranquillity Base. The rover moves at "about a human walking pace," says Gump, and will have to reach its destination before nightfall, so success requires a precision landing. The team expects to come down about half a mile from its target, with a precision measured in meters—unprecedented accuracy for a robotic planetary lander.

This is where another Astrobotic partner, Raytheon, comes in. The company built the Navy missile that intercepted and destroyed a military reconnaissance satellite falling from orbit last February. Astrobotic will license the Raytheon "digital scene matching" technology used in cruise missiles—which compares real-time pictures of the looming target with photos stored in an onboard computer—to ensure precise navigation.

Another serious contender to win the Google prize is Quantum3, based in Vienna, Virginia, and led by NASA veterans including Courtney Stadd, the agency's former chief of staff, and Liam Sarsfield, its former deputy chief engineer. Quantum3 is counting on a new method of landing that Stadd says is different from what other teams are using. Then, instead of rolling on wheels, the lander will "hop" around the surface with small rocket blasts. The price tag, says Stadd, is much lower than $100 million, but is still more than the Google prize money. Like Astrobotic, Quantum3 is heading for the Apollo 11 site. As of May, Stadd still hoped his team could make it there by the 40th anniversary, in July 2009.

All the proposed traffic around Tranquillity Base makes some in the space community worry that the historic Apollo sites will get trampled. Beth O'Leary, a New Mexico State University anthropologist who has led a campaign, so far unsuccessful, to declare the Apollo 11 site a national historic landmark, is concerned that the robots could inadvertently destroy a priceless artifact. Despite the best intentions of the X Prize teams, she says, "it's untried technology."

So far, it's a controversy without much argument. "Our top priority is protecting Apollo 11 from any disturbance," says Gump. "We're not rolling over any footprints." Astrobotic's rover will stay outside the perimeter of Armstrong and Aldrin's farthest travels, he says. Pictures of the lander will be taken from a "respectful distance" with a telephoto lens.

Gump hasn't given much thought to what the pictures will show. But he looks forward to the adventure playing out on live TV, "like opening Al Capone's vault."

Might the photos, like the vault, prove disappointing? There's a chance—a very remote one—that the lander has been destroyed by a meteoroid. We know of at least one Apollo artifact that's still intact, though, right where Aldrin left it on July 21, 1969. Tom Murphy and his colleagues at the University of California at San Diego still interact with it regularly. Every few nights, they point a laser at a quartz prism on the surface. Then the scientists time the beam that bounces back, a measurement useful for gravitational physics studies. In the two years he's been pinging the Apollo retro-reflectors, Murphy has become increasingly puzzled. Despite the exquisite sensitivity of his instrument on Earth, the signal that bounces back from the moon is 10 times weaker than it should be. After ruling out other explanations, Murphy has come up with a tentative theory: The reflectors left on the moon have degraded over time. Maybe, he thinks, they have been lightly etched by all those sharp dust grains bouncing around for years on the lunar surface. If so, the once-pristine glass may now be frosted, which would explain the loss in signal strength.

It's the kind of thing NASA engineers planning the next lunar outpost would love to know. The rest of us just want to find out what happened to the flag. We may not have long to wait.

Lunar Litter

NEIL ARMSTRONG and Buzz Aldrin left behind 66 items at Tranquillity Base, from their removable lunar overshoes (which actually stamped the iconic bootprints in the dust) to a "urine collection assembly, large" and sick bag (presumably unused – none of the Apollo 11 astronauts reported throwing up during the mission). Armstrong and Aldrin stuffed personal items in a large bag and threw it overboard just before leaving. Other objects still on the surface include tools; a TV camera, its stand, and cable; and a clothesline-like contraption for hoisting equipment back into the lander at the end of the moonwalk. The astronauts also left a mission patch memorializing the astronauts killed in the Apollo 1 launch pad fire; medals honoring Soviets Yuri Gagarin, the first human in space, and Vladimir Komarov, the first person to die during a space mission; a silicon disk etched with messages from world leaders; and a small, gold olive branch as a sign of peace.

LIVE AND LET

REAL PILOTS RATE THE PERFORMANCE OF THE AIRPLANES IN JAMES BOND FLICKS.

BY DAVID LANDE

Whether it's a desperado using the rotors to try to slice 007 to ribbons, or Bond himself using the vehicle to escape (below, *Die Another Day*), the humble helicopter puts the action into action films.

EVER SINCE AUDIENCES first saw British secret agent number 007, tangling with a claw-handed villain in the 1962 film *Dr. No*, James Bond has branded the concept of cool. This November, he's back—in a new Bond film, *Quantum of Solace*, which, like its predecessors, showcases the kind of fare worthy of Ian Fleming's suave super-spy: girls, gadgets, sports cars, and, best of all, airplanes.

At some point in every Bond film, the action takes to the sky. The aircraft, ranging from Harriers to Cessnas to hang gliders and flown by friend and foe, are typically cutting-edge for the time. The Bell Aerosystems rocket belt that propelled Bond to safety in *Thunderball* (1965) had been recently developed under a U.S. Army contract. The little autogyro in *You Only Live Twice* (1967) was a fresh design of record-setting pilot Ken Wallis. In *Moonraker* (1979), the now-familiar space shuttle blasted off the big screen two years before the maiden launch of the real thing. But in the upcoming *Quantum of Solace*, the airplanes have been around a while—a Douglas DC-3A built in 1939 shares the screen with a sleek and sinister black SIAI-Marchetti SF.260TP, a descendant of a 1960s design.

Sure, these aircraft are cool. But are they *Bond* cool? We ask real-life pilots to weigh in.

Wallis WA-116 "Little Nellie" Autogyro

The autogyro—a rotorcraft using an unpowered overhead rotor acting as a circular wing to create lift—has been around a long time. In 1931, Amelia Earhart set a woman's world altitude record in one—a Pitcairn PCA-2 that she flew to 18,415 feet. But Harold Pitcairn could not have imagined his design's mutation into the tiny terror of *You Only Live Twice* (1967). Bond's WA-116, nicknamed "Little Nellie," is armed to the teeth with missiles, machine guns, rocket launchers, and even flame-throwers. Bond needs all these weapons to dispatch four bullet-spitting SPECTRE helicopters in hot pursuit. Score for the day: Bond 4, SPECTRE 0.

Nellie's creator, Wing Commander Ken Wallis, became a Royal Air Force pilot in World War II. After retiring from the RAF in 1964, he concentrated

FLY

THE KOBAL COLLECTION (2)

In *You Only Live Twice*, Sean Connery flies an autogryo souped up with missiles, machine guns, and flame-throwers.

full time on developing autogyro technology. He's set many autogyro records, including speed, time to climb, duration, and altitude.

Wallis himself flew his WA-116 in the Bond movie. Now 92 and living in Norfolk, England, Wallis recalls, "I did 85 takeoffs and landings, and flew for 46 hours," which translated into seven and a half minutes of pure excitement on the screen. "The helicopter pilots had to ask me to slow down, because they could not keep up with Little Nellie in level flight and while climbing."

Film footage alternates between air-to-air views of Wallis from a distance and close-ups of Sean Connery in the cockpit. The two men were similar in build, "but Connery's arms were considerably hairier, and that can be seen in the movie if you look closely," says Wallis. Connery's scenes were filmed in a studio before a blue screen (to enable fake backgrounds to be used), while Wallis' were filmed high in the skies over Spain and over Japan's Sakurajima volcano.

Another record-setting autogyro pilot, Andy Keech, who has 450 hours in seven autogyro types, says of the WA-116: "It was the most sympathetic machine I had ever been in. The blades of the WA-116 are quite short, relative to other gyros, at 20 feet. They are therefore very smooth and there is no feedback into the stick. It is as smooth to fly as a Piper Cub."

In a coded message to HQ, Bond described Little Nellie's reception: "Four bigshots made improper advances toward her, but she defended her honor with great success." Packing heat, Little Nellie is tailor-made to fit Bond cool.

Despite sluggish engines and high fuel consumption, the JetStar, says corporate pilot Neil Looy, has lovable airliner qualities.

Lockheed L1329 JetStar

EON Productions evidently liked the Lockheed JetStar so much that it was awarded two roles in *Goldfinger* (1964). It first appears as the executive aircraft of criminal mastermind Auric Goldfinger, and later reappears as a C-140 military transport.

As a corporate pilot, Neil Looy flew 3,000 hours in several iterations of JetStars. "At the time the plane came out, it was the premier corporate jet," he says. "It was built like an airliner. A little more complicated than some of the Learjets and Gulfstreams that would come out on the market."

With its four tail-mounted engines, "you could practically see the gas gauges moving—those four little Pratts were burning that much JP-4 [fuel]," he says, referring to the Pratt & Whitney JT12A-6 turbojets. Yet even with the four engines it's underpowered, impotent to climb to cruising altitude as long as the tanks are full. "You had to stair-step to get up to altitude, like the airliners," says Looy. "With the 731 version of the JetStar [equipped with Garret AiResearch TFE731-3 turbofan engines], I'd get up to 35,000 feet and have to wait until I burned off fuel before I could bring it up to higher altitude, burn more fuel, and go up higher."

Still, Looy loved the JetStar for its airliner qualities—"so large, heavy, and roomy. Wonderful to fly." And the novelty of an executive luxury jet was no doubt cool for 007 audiences to see in 1964.

While certain deficiencies can be overlooked, any kind of impotence automatically disqualifies an aircraft from Bond cool.

Bede BD-5J Acrostar Micro-jet

Ever wonder what it would be like to strap on a micro-jet and shriek across the sky? Ask the man who built and flew the one in *Octopussy* (1983). That pilot is J.W. "Corkey" Fornof, who, when flying past at more than 300 mph, also passes as a credible double for Roger Moore. Fornof has 1,000-plus hours in his TRS-18 microturbo-powered Bede jet. And he figures he and his friends spent 3,300 hours building it.

The memorable opening of *Octopussy* shows his Acrostar evading a ground-to-air missile by flying through a hangar, but it soon runs out of fuel, so Bond nonchalantly lands on a road and coasts to a stop at the pumps of a service station. Except for the ground-to-air missile, the scene's action came directly from Fornof's personal experience.

While he was flying near Winston-Salem, North Carolina, his BD-5J lost oil pressure and he was forced to land on a highway. "Once on the ground, I went down the exit ramp and coasted into a gas station, just like in the movie, and ran over the little hose that went *ding ding*," he recalls. He has a clipping from the local newspaper documenting the event.

Prior to the movie, Fornof had flown the Acrostar through an open hangar for a Toshiba commercial in Japan. After Bond producers Michael Wilson and Cubby Broccoli saw it, they wanted similar action in their upcoming film.

About his "kids, don't try this at home" stunt, Fornof explains that he opened all the hangar's doors and windows to reduce the sudden pressure increase caused by an aircraft trying to push a lot of air through an enclosed space. He calculated that, given the frontal area of the BD-5 and the size of the hangar, airspeed couldn't exceed 180 mph. If he went too fast, "the pressure feedback would probably have caused me to bounce off the floor and into the rafters," he says. "As I approached the hangar, the opening looked very small. I had exactly six feet below me and six feet above me. My heart was in my throat. I don't think I took a breath for a minute and a half." The stunt came off perfectly.

"The Acrostar is in my top five favorite airplanes of all time," he says. "It's like driving a Formula One racecar compared to a regular sedan."

The Acrostar used in *Octopussy* is still Fornof's airplane, now on loan to the Museum of Flying in Santa Monica, California. It is the quintessential Bond airplane and a scene-stealer in the coolest 007 opening sequence ever.

ANDRE AGUIRRE/AIRTEAMIMAGES

The Space Shuttle

In *Moonraker* (1979), Bond joins forces with Holly Goodhead, an alluring NASA astronaut and CIA agent, and together they commandeer evil genius Hugo Drax's space shuttle just before takeoff to foil his plan for world domination. A *tad* far-fetched, but that didn't stop *Moonraker* from raking in more than $210 million at the box office.

Aside from some over-the-top fiction, parts of *Moonraker* are plausible. Women have piloted—and commanded—space shuttles. The first was commander Eileen Collins. Over the course of four shuttle missions, Collins spent a total of 36 days in space.

The movie also accurately depicts that at crucial points, such as the rendezvous for docking at a space station, the shuttle is controlled manually. Under manual operation, Collins says flying the space shuttle is similar in some ways to flying conventional aircraft. (During her years with the U.S. Air Force and NASA, she has logged more than 6,700 hours piloting 30 types of aircraft.) To line up the shuttle for docking, "you have the six degrees of freedom," she explains. "The six axes are roll, pitch, and yaw, and the translations x, y, and z, which are right/left, in/out, and up/down."

During the return to Earth, the crew again takes manual control. "The first part of reentry is done on autopilot, until you go subsonic," Collins explains. "Once you go under Mach 1, the commander takes control and flies it down to the landing. The commander makes the landing on every shuttle flight. We've never done an auto-landing." (Of course, we never see the shuttle land at the end of *Moonraker*, because of Bond's romantic dalliance with his pilot in the zero-gravity cargo bay.)

Top: Fleeing a heat-seeking missile, Bond outwits foes in *Octopussy* by flying his micro-jet through a hangar. Above: The noble space shuttle inspired a dastardly plan in *Moonraker*.

As the first space shuttle ever, it's Bond cool.

TOP: THE KOBAL COLLECTION; RIGHT: SCOTT ANDREWS

The Harrier jump jet – good for getting out of tight situations – should be standard issue for every super-spy.

British Aerospace Harrier T.10

Few sights in aviation are more impressive than a Harrier roaring straight up, hanging suspended for a moment, then screaming forward into the blue. The V/STOL (vertical/short-takeoff-and-landing) attack aircraft, designed in Britain and further developed in the United States as the AV-8B for the Marine Corps, does just that in *The Living Daylights* (1987).

The scene showing a two-seat T.10 spiriting away the defecting Soviet general Georgi Koskov lasts only one minute, perhaps because theater audiences now so accustomed to computer-generated imagery no longer appreciate seeing an airplane that's *really* capable of a spectacular repertoire.

What does a veteran with 2,600 hours in Harriers say about the sensation that comes with V/STOL? Retired U.S. Marine Major General Joe Anderson says, "It is a shot of adrenaline, and it never diminishes."

Anderson, the deputy director of the Smithsonian Institution's National Air and Space Museum, has flown a British Aerospace two-seat Harrier at England's Farnborough International Airshow, taking off from a ski jump. Such a takeoff "feels like a soft catapult shot," he says. "The Harrier accelerates faster than anything else I've flown."

Anderson acknowledges that the poor reputation of the early Harriers (known in the U.S. as the AV-8A), such as being underpowered and being vulnerable when taking off and landing vertically, has "stuck," and that some people might think those early demons continue to dog the second generation of Harriers. But, he says, the weaknesses have been overcome: "The AV-8B was greatly improved by upgraded avionics, including a state-of-the-art HUD [head-up display], improved stability augmentation systems, and a supercritical wing."

Art Nalls owns the only flyable Harrier in civilian hands. "It's still a remarkable piece of engineering," Nalls says, "uniquely designed to...conquer various parts of the flight envelope." He recalls an incident as a Marine Corps aviator: "On one flight off the coast of Beirut, I succeeded in touching all the corners of the authorized flight envelope. I took off from the deck of the USS *Tarawa* and dropped down to skim the water, climbed to 42,000 feet, dove down and broke the sound barrier, and landed at zero airspeed. No other airplane at the time could do that. Sea level to 42,000 feet, zero to Mach 1. What a beast!"

Where does the Harrier register on the Bond cool-o-meter? It's waaay cool.

RICHARD VANDERMEULEN

SIAI-Marchetti SF.260TP

In *Quantum of Solace*, the bad guy guns for Bond in an all-black SIAI-Marchetti SF.260TP, which has performance enough to make Bond's long-suffering gadget whiz "Q" envious. For the movie, Steve Hinton, veteran Hollywood stunt pilot, flew the Italian military trainer for about 70 hours near San Felipe, Mexico.

"Its handling qualities feel quite a bit like a fighter airplane," says. He should know: He's flown about 30 types of fighters, both piston and jet-powered. "If you don't look at the airspeed indicator, it feels a lot like a P-51. You can pull it around corners, you can fly it upside down, and you can loop it. It's got a 6 G limitation on it, and built very strong. He adds that "the plane has a pretty wide range of operation," with good slow speed handling qualities as well—necessary for flying behind a DC-3 with Bond aboard and to match the speed of camera-toting helicopters (although a very capable Aerostar camera platform did much of the filming).

Hinton says that turboprop engines suffer a drop in performance in hot weather—a factor in Mexico, where during filming temperatures ranged from 50 to 80 degrees. "But it had plenty of power to do the kind of flying we needed," he says. "For filming, you push it to the limit, within its limits. We did a lot of really low-level flying, head-on passes, inverted rolling, looping, Cuban-eighting, and pulling up to go over canyon peaks."

Hinton cites one weakness: The gas-slurping, turbine-powered ("TP") version of the SF.260 has a small fuel capacity. He says the aircraft can go about two and a half hours before refueling, but "when you do the high-power, low-level thing, you're out of gas after two hours. And when it takes you 20 minutes to get to location and 20 minutes back, you're left with not much time to shoot."

Some Bond-watchers were surprised by the choice of this older, somewhat exotic piston airplane, but perhaps the producers saw the SIAI-Marchetti in the tradition of the famous vintage Aston Martin DB5 sports car that appears perennially in Bond films, first in 1964's *Goldfinger* and more recently, in 2006's *Casino Royale*, in enemy hands.

Like fine vintage wine, the SIAI-Marchetti is Bond cool.

Piper Cherokee PA-28

Even a pedestrian airplane like a Cherokee can be fun to watch, especially when the five of them that make up Pussy Galore's Flying Circus fly in close formation in *Goldfinger* (1964). That formation is an early example of major product placement, in this case for Piper Aircraft's newest model.

Dennis Boykin, who has logged more than 1,200 hours in Cherokees, reports that his wife, Joyce, is a huge Bond fan. "Every time we watch *Goldfinger*, she mentions the Cherokees, as in 'Dennis, here comes your favorite part,' " he says. Their first date was in his Cherokee—a 120-mile flight to Kansas City, Missouri, for dinner. As the ultimate affirmation for a pilot and airplane, "she slept through the landing. I knew right then she was my new copilot. She's been falling asleep in my airplane for 20 years now."

Of course, Boykin is a diehard proponent of the model and a card-carrying member of the Cherokee Pilots' Association. "The airplane is built like a tank, with a carry-through spar that goes under the rear seat," he says. "The structure is very survivable in an accident"—good news whether you're flying with Bond or against him. "The constant-chord wing, also known as the 'Hershey Bar,' is one of the most forgiving airfoils ever produced. It's nearly impossible to get the Cherokee to produce a classic stall—mostly it just 'mushes.' "

The Piper Cherokee starred in *Goldfinger* as the aircraft for Pussy Galore's Flying Circus (they were actually piloted by men wearing blonde wigs).

When asked if anything memorable has ever happened while flying his Cherokee, Boykin offers an immediate Bond-like response: "Yes, but one of them isn't for publication in a family magazine."

That answer alone averts a thumbs-down.

GEORGE KOUNIS

Aero Vodochody L-39 Albatros

In the first 10 minutes of *Tomorrow Never Dies* (1997), Bond nimbly maneuvers an L-39 out of the way of a cruise missile at a terrorist arms bazaar in the Khyber Pass. The Czech military trainer has become popular with civilians for its agile handling, and has become a standard attraction at the National Championship Air Races in Reno, Nevada, where it debuted in 2002 in the new Jet Class races. L-39 pilot Glenn Goldman, an airline pilot for 20 years, has flown about 70 airplane types, from 767s to piston-driven warbirds. He's also a licensed mechanic.

"It's an incredibly reliable airplane," says Goldman, who has tinkered with the L-39 as well as flown it. "The engineering is top-notch, the construction is top-notch. Very simple and easy to maintain."

As for flying, "the airplane has very few vices," he says. "It's got well-harmonized controls. You really don't have to think when you want to turn. It's almost intuitive how much aileron to put in, how much rudder, and how much back pressure to maintain altitude. It uses push rods, and since push rods run on bearings, it's very smooth on the controls."

On the other hand, Goldman feels there's no challenge, no satisfaction of the kind found in mastering the older warbirds. "It's a boring airplane to fly," he says. "I could teach my grandmother to fly an L-39."

And if the advanced trainer/light attack aircraft were intended to pass for a MiG (since the movie has it armed with "Soviet SB-5 nuclear torpedoes" on the wings' hard points), then it's decidedly uncool in another respect: A real MiG of the era, such as the MiG-29, could fly Mach 2-plus and carry an 8,816-pound warload. Which means the MiG, its pilot yawning and writing a letter to his girlfriend in Moscow, could fly circles around the straight-winged L-39, which reaches only 390 mph in level flight and carries a third of the armament.

Does the L-39 deserve distinction as Bond cool? Sorry; "grandmotherly cool" doesn't cut it.

The L-39 had its own class at the Reno Air Races until 2007, when the competition was opened to other straight-wing, no-afterburner jets.

RICHARD VANDERMEULEN

Bell Aerosystems Rocket Belt

After Bond uses a Bell Aerosystems rocket belt to make a slick getaway from SPECTRE henchmen in *Thunderball* (1965), a whole generation of kids grew up fantasizing about free flight over the neighborhood. The movie stays true to the capabilities of the peroxide-fueled device: Bond soars overhead and remains there for 20 seconds, just inside the rocket belt's 21-second flying limit.

Bill Suitor, the actual rocketeer for the movie, says, "When you strap the belt to your back, you become part of it and it becomes part of you. But you only have 21 seconds—there's always that time element."

As a pop culture novelty from the 1960s, it's cool. But for the same reasons the U.S. Army discarded the idea (flight time, unstealthy howl, instability), the rocket belt falls one belt-loop short of Bond cool.

The rocket belt's potential users included flying commuters, camouflage-clad rocket soldiers, an aerial police force – and, of course, spies.

AFTER 46 HOURS, 22 BAGS OF POPCORN, and a trashcan-size soda, the editors at *Air & Space* have finished watching all of the Bond flicks, counting more than 150 aircraft and spacecraft (both fictional and non-). Bond and company have flown just about everything, from "Bird 1" (Ernst Blofeld's fictional two-stage rocket used to capture U.S. and Soviet spacecraft) in *You Only Live Twice* to the Aerospatiale/Eurocopter helicopter operated by psychopath Xenia Onatopp (who uses her thighs to crush her opponents to death) in *GoldenEye* to the hot-air balloon blown up by the Cigar Girl assassin in *The World Is Not Enough* to the fictional "Skyfleet S570 prototype" (the world's largest passenger aircraft targeted by terrorist banker Le Chiffre) in *Casino Royale.*

Learn more by visiting *www.airspacemag.com.*

THE KOBAL COLLECTION

Resto

Cleaning a Carrier | USS *Intrepid*

AFTER SPENDING 24 YEARS tied up at Pier 86 on Manhattan's west side, the aircraft carrier *Intrepid* and its pier both needed a good cleaning—$60 million worth. During the highest of high tides, on November 6, 2006, the ship was to be moved into drydock. In preparation, dredges pumped out 15,000 cubic tons of muck from its sides and path, and crews pumped 600 tons of water from the carrier's ballast tanks. The move was covered live on CNN. Dignitaries spoke, and then 80-year-old retired Rear Admiral. J. Lloyd "Doc" Abbot Jr., the *Intrepid* skipper from 1960 to 1962, ordered the mooring lines cast off. Six tugboats, with a combined 30,000 horsepower, shoved the ship into the Hudson River. *Intrepid* made it all of 15 feet before its screws—its propellers—got stuck in the mud.

The tide went out, the dignitaries went home. Finally, a month later, after further dredging, the ship budged, and tugboats towed it downriver to Bayonne, New Jersey, for a few months in rehab. There its hull underwent repairs, its problem-prone screws were removed, and its exterior got a new paint job. After the hull and deck dried, the ship was once again moved, this time to nearby Staten Island, for the restoration of more than 80,000 square feet of its top three decks.

Intrepid was one of 24 Essex-class carriers cranked out in East Coast shipyards during World War II. Barely slim enough to squeeze through the Panama Canal, each carried up to 100 airplanes and 3,000 men and played a critical role in the Pacific theater. Four survive today, all as museums: The *Yorktown* at Mount Pleasant, South Carolina; the *Hornet* at Alameda Point, California; the *Lexington* at Corpus Christi, Texas, and the *Intrepid*. Known as the "Fighting I," the *Intrepid* was home to a variety of aircraft: Grumman F6F Hellcats and TBF-TBM Avengers in World War II, F9F Cougars and F11F Tigers during the 1950s, Douglas AD Skyraiders and A-4 Skyhawks on the ship's cruises during the Vietnam War. In all, the carrier survived five kamikaze attacks, three wars, three decommissionings, and a near-scrapping before real estate developer Zachary Fisher rescued it and had it towed from Philadelphia to New York City in 1982.

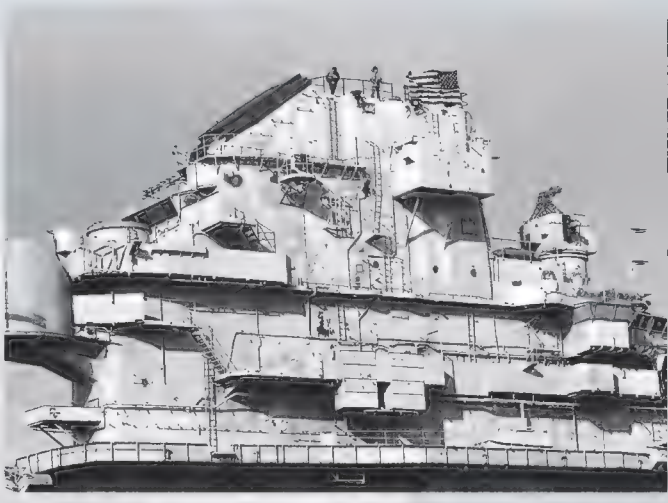
Of the four carrier-museums, the *Intrepid* was the least ship-shape. By the time the carrier was sent for restoration, worn, stained, indoor-outdoor carpeting covered the hangar deck, and generations of ad-hoc wiring and lights dangled from the ceiling. "Over the years, things had gotten confused," explains chief curator John Zukowsky. And a lot of color had been lost: Everything neither carpeted nor painted battleship gray had been given a coat of institutional white. "Ships were colorful, lively places," Zukowsky adds. "In naval vessels, pipes were color-coded to be easily identifiable in emergencies."

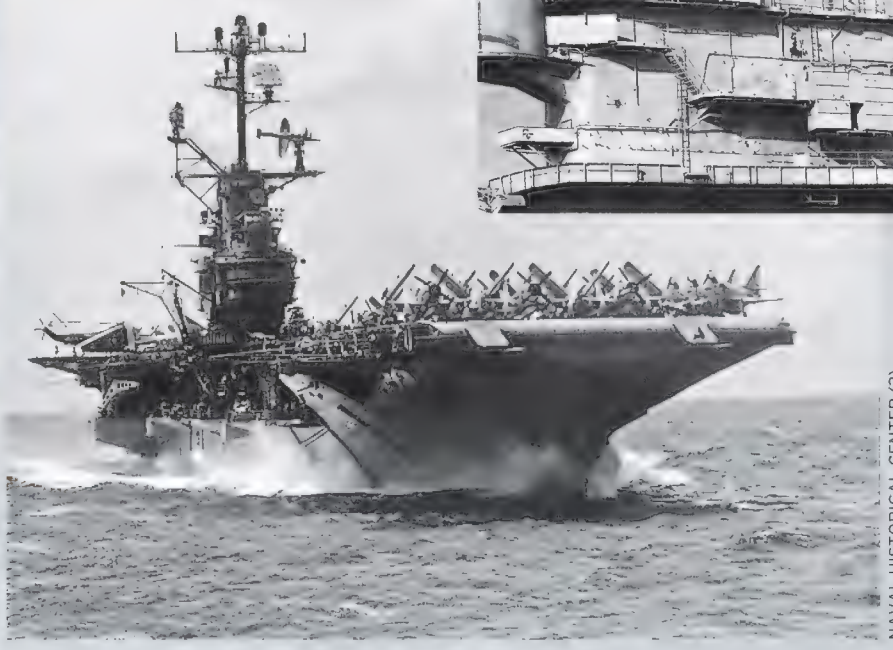
Now a small team of electricians is removing wiring and installing new, unobtrusive but energy-efficient fixtures. Then Navy-regulation paint colors will be ap-

MICHAEL PENDERGRASS/DOD

The 900-foot-long aircraft carrier *Intrepid* towers over the U.S. destroyer *Edson* during Fleet Week 2002 in New York City. For its overhaul, the floating air and space museum got a tug from a smaller boat (opposite, top) from its berth in lower Manhattan in December 2006, to Bayonne, New Jersey.

Below: The *Intrepid* took part in every major Pacific battle in the last two years of World War II. Right: a port quarter-view of the ship's island.





NAVAL HISTORICAL CENTER (2)

TIMOTHY A. CLARY/AFP/GETTY IMAGES

plied, the carpeting will be stripped, and the deck will receive a fresh coat of gray in preparation for a new exhibit about World War II, the carrier, and the men who fought and died on it.

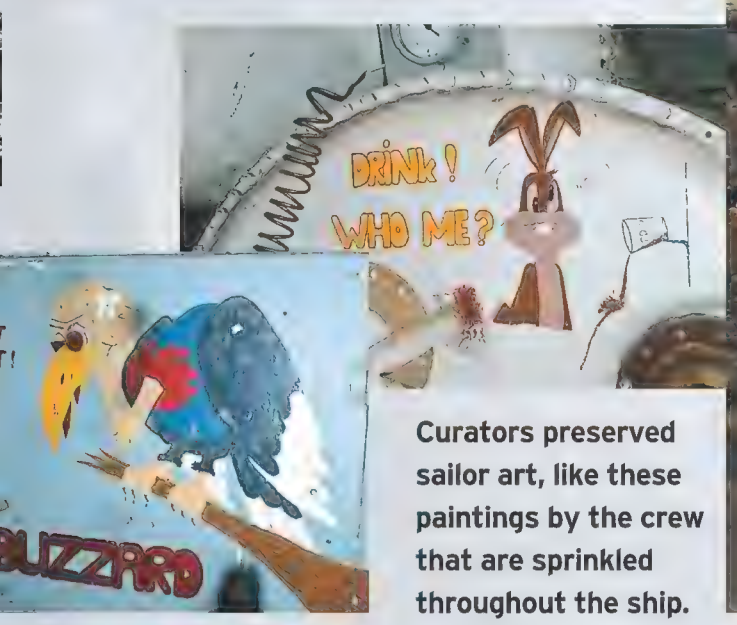
Other parts of the *Intrepid* are being restored to near-original condition. During more than 30 years in service, *Intrepid* underwent several major modifications, including a new angled deck and steam catapults. The restoration work will maintain those modifications. During the ship's last cruise, in the early 1970s, the mess was divided into smaller rooms that were decorated with homey touches. Restorers are using photos to re-create two of them, as well as several quarters for officers and enlisted men.

During the restoration, most of the aircraft remained on the ship, wrapped in material to protect against overspray. When restorers did turn their attention to the aircraft, they mostly did corrosion repair and prevention, replaced damaged Plexiglas canopies, researched historic paint schemes, and, when feasible, returned an airplane to its original colors.

This fall, the restoration will be finished, and on October 2 the ship is scheduled to be towed back to Pier 86, where 46th Street meets the Hudson. On the new hangar deck an exhibit of aircraft will focus on the ship's history, with a Grumman TBM Avenger, a North American FJ-3 Fury, a Piasecki HUP-2 Retriever, and a Douglas A-4B Skyhawk. On the flight deck will be other historic favorites, including a General Dynamics (now Lockheed Martin) F-16, a Lockheed A-12 , and a McDonnell F-4 Phantom. The ship is scheduled to be reopened to the public on November 8. This time, though, there won't be any problem with the screws: They'll be on exhibit, topside.

PHIL SCOTT

A Grumman F11F Tiger (left) leaves the ship for a trip to Ohio, where it will be repainted as the Blue Angel it once was. The carrier (below) waits in drydock in New Jersey, stripped of four giant bronze screws, each weighing 30 tons and measuring 16 feet in diameter.



Curators preserved sailor art, like these paintings by the crew that are sprinkled throughout the ship.

RUBENSTEIN ASSOCIATES (5)

THE DISORIENT EXPRESS

Despite the best training and technology, why do pilots still die from not knowing which end is up? by Tom LeCompte

ON JUNE 26, 2007, while on a training exercise off the Oregon coast, Major Gregory D. Young of the Air National Guard flew his F-15A fighter into the Pacific Ocean. The $32 million aircraft was destroyed and the pilot killed. There was no distress call, no attempt to eject, and no apparent aircraft malfunction. Young, 34, had 2,300 hours of flight time, more than 750 hours of it in F-15s.

As investigators sifted through the wreckage—what little was left—colleagues, family, and friends were left to wonder: What caused Young to guide his airplane right into the ocean at more than 600 mph? The answer, revealed in an investigative report two months later, was both profoundly unsettling and all too familiar. Young, in the prosaic terminology of the report, "experienced unrecognized (Type 1) spatial disorientation (SD), which caused him to misperceive his attitude, altitude, and airspeed. As a result, [he] was clearly unaware of his position and impacted the water."

In other words: Young never knew what hit him.

Despite training, experience, and technology, all based on knowledge of how flight affects human physiology, Young had no idea that he was racing downward.

Once called pilot vertigo or aviator's vertigo, spatial disorientation is a persistent killer. Federal Aviation Administration statistics show that the condition is at least partly responsible for about 15 percent of general aviation accidents, most of which occur in clouds or at night, and 90 percent of which are fatal. According to a 2004 study, the average life expectancy of a non-instrument-rated pilot who flies into clouds or instrument conditions is 178 seconds.

A U.S. Air Force review of 633 crashes between 1980 and 1989 showed that spatial disorientation was a factor in 13 percent, resulting in 115 deaths. Among crashes of high-performance aircraft, the rate was higher: 25 to 30 percent. A U.S. Navy study found that in contrast to general aviation accidents, a majority of accidents in high-performance aircraft occurred in daylight and in visual flight conditions. The pilots were an average of 30 years old, with 10 years in the cockpit and 1,500 hours of pilot-in-command or instructor time, and in the prior three months they had flown an average of 25 times—all of which shows that no amount of expertise, training, or experience immunizes against spatial disorientation.

Humans maintain orientation and posture through a system of senses: vision; the vestibular system (the labyrinthine series of ducts and canals in the inner ear); muscle-sense or proprioception, sensors in muscles and joints that inform us of our body's position (standing versus sitting, for example); and the sense of gravity, or what we perceive as up and down. The system has evolved over eons, and is well adapted for Earth. But it is easily fooled. When you're sitting on a stopped train and the train on an adjacent track begins to move, you'll think that you're the one who is moving.

In the air, things get more complicated. Early aviators were confronted by an assault on their senses, or "disturbances of equilibrium," as Orville Wright described it. Until World War I, most flights were made during the day and limited to short, straight-and-level hops. Few risked flying at night, and fewer still flew into clouds, or at least did and lived to tell about it.

At Wright-Patterson Air Force Base in Ohio, a study subject is wired for a spin in the Dynamic Environment Simulator, a centrifuge that excels in inducing spatial disorientation.

DEPT OF DEFENSE

Research in the 19th and early 20th centuries helped shed light on the vestibular system and how it maintains equilibrium. In 1906, Robert Barany devised a swivel chair to simulate the effects of spatial disorientation on pilots.

At an FAA-sponsored safety seminar in Rhode Island recently, program manager Jack Keenan offered me a seat in a Barany chair, a device not unlike a barber's chair, with an ersatz control stick. As a group of other pilots stood around, he blindfolded me and began to spin the chair to the left, telling me to move the control stick in the direction of the spin. I dutifully moved the stick to the left.

As Keenan gently turned the chair, he said to the group, "Your body keeps you alive. We learn to recognize cues from our environment." The problem, he added, "is that our bodies are meant to walk on Earth." As he spoke, the chair seemed to quit spinning. I moved the stick to the neutral position. Keenan then rattled off a litany of phenomena ready to befall pilots: the leans, the graveyard spiral, the inversion illusion, the elevator illusion, false horizons (see "Vertigo: A Primer," below). As he spoke, the chair then seemed to reverse direction, spinning to the right. I moved the stick to the right. Some in the group tittered. Keenan then pulled off the blindfold, and I saw that the chair had stopped. "Get up carefully," warned Keenan, helping me to my feet. "You're still spinning." Three other volunteers followed my lead. In each case, Keenan first got the chair spinning. After a bit, he gently brought the chair to a stop. In each case, the volunteer moved the stick exactly as I did.

The inner ear is designed to detect motion, or rather, acceleration. Thus, when the chair began to turn, I sensed it. However, once the turn rate was constant, the fluid in my inner ear returned to equilibrium, and without the benefit of visual cues, I could not tell the difference between turning and sitting still. So when the chair stopped turning, I sensed that as a turn in the opposite direction.

Vestibular illusions fall into two categories: somatogyral, for spinning illusions ("somato" is Greek for "body"), and somatogravic, for acceleration illusions. The Barany chair demonstrates a basic somatogyral illusion. An airplane in a stable, level turn will feel the same as an airplane in straight-and-level flight. If the airplane is returned to straight-and-level flight, or if the bank is decreased, a pilot's natural reaction would be to make a correction that would steepen the actual turn. If at the same time the pilot's head were tilted—if he were reading a map or picking up a pencil—the deception to the vestibular system would be compounded along a third axis, meaning that when the airplane returned to straight-and-level flight or the pilot lifted his head, he would sense not only a turn in the opposite direction but a feeling of pitching up or down.

Somatogravic illusions refer to situations in which an airplane that begins accelerating will feel the same as one climbing, and an airplane decelerating will feel the same as one descending. Because we live on the surface of the Earth, where the force of gravity pulling us toward the ground is more or less constant, or 1 G, our vestibular system cannot distinguish the difference between pitch and acceleration. Today's full-motion simulators take advantage of this fact to create the illusion of flight. For example, inside the simulator pod, as the pilot moves the throttles forward for takeoff and sees and feels the "airplane" accelerating down the runway, the pod itself begins to tilt up. The motions created by the simulators are so realistic that students have become airsick in them.

In 1917, Elmer Sperry invented the gyroscopic turn indicator, based on a similar device he had invented for ships. The indicator joined Sperry's gyroscopic compass to make up what would later be the core of the panel for instrument flight. But as late as 1928, the idea of flying solely by reference to instru-

Vertigo: A Primer

SPATIAL DISORIENTATION is classified into three types.

- Unrecognized spatial disorientation (Type I) refers to situations in which the pilot fails to perceive a change from the desired orientation.
- Recognized spatial disorientation (Type II) occurs when the pilot realizes there is a conflict between the flight instrument readings and what his body senses is the spatial orientation.
- Incapacitating spatial disorientation (Type III) refers to situations in which the physical symptoms accompanying disorientation – visual impairment, muscle spasms, nausea, or panic – are severe enough to incapacitate the pilot.

Among the illusions pilots may experience:

The Leans A somatogyral illusion in which, after a prolonged, gentle turn followed by a sudden return to level flight, a pilot will sense a turn (bank) in the opposite direction. A pilot experiencing the leans may lean in the direction of the original turn in an attempt to regain the perception of the correct vertical posture.

The Coriolis Illusion A somatogyral illusion in which, while the aircraft is turning, a pilot tilts his head – say, to read a map. When the head is tilted out of the plane of rotation, the pilot will experience a sensation of rolling. Depending on the nature of the turn, the pilot may also experience a sensation that the aircraft is pitching, yawing, or both.

The Graveyard Spiral Unaware the airplane is banked but sensing the nose drop and a loss in altitude, a pilot may pull back on the yoke to try to regain altitude or slow the rate of descent. The increase in back pressure on the control yoke usually results in a tighter turn and a drop of the nose, causing a further loss of altitude. The sequence may continue until the airplane stalls, breaks apart, or hits the ground.

The Inversion Illusion A somatogravic illusion in which, after a sustained climb in a high-performance aircraft, the pilot levels the aircraft, creating a lighter "seat bottom" sensation while the acceleration maintains the seat-back pressure. The sensation is that of the aircraft continuing to increase in pitch. Soon the pilot perceives the aircraft is inverted.

ments—"flying blind"—remained as foreign as travel to other planets. Pilots were convinced that their most valuable tools were skill and instinct.

In 1926, Army Air Corps Captain William Ocker, who had been experimenting with Sperry's turn indicator, took a medical exam that included a spin in a Barany chair to test his vestibular system. Experiencing the same spinning illusion, he had the revelation, writes William Langewiesche in *Inside the Sky* (Pantheon, 1998), "that instinct is worse than useless in the clouds, that it can induce deadly spirals, and that as a result having gyroscopes is not enough, that pilots must learn against all contradictory sensations the difficult discipline of an absolute belief in their instruments." Ocker, with the zeal of a fundamentalist minister, began preaching the necessity of developing procedures and instructional programs in instrument flight. He was unable, however, to convert his superiors. Twice the Army had Ocker hospitalized to test his sanity. (In 1932, a vindicated Ocker coauthored the first treatise on instrument flying, *Blind Flying in Theory and Practice*.)

In the 1920s, the Ocker Box (above) showed flying students how to counter vertigo by looking only at the instrument panel. The balancing chair (left) assessed a cadet's ability to maintain equilibrium.

In 1927, a group of scientists and pilots that included Sperry and Army Air Corps Lieutenant James Doolittle built an artificial horizon, a gyroscopic device that gives the pilot a graphic representation of the airplane's attitude in relation to the horizon. Doolittle used it in 1929 to make the first flight and landing solely by reference to the aircraft's instruments, proving the feasibility of instrument-only flight.

Making trustworthy instruments was one thing, but making pilots trust them was another. At first, pilots reported the instruments seemed to work only in clear weather, that in clouds the devices went haywire, indicating turns the pilot was certain the airplane was not making. The instruments worked just fine; the pilots had to be taught to resist the instinct to fly "by the seat of their pants"—that is, by sensation alone.

Today, primary flight training for all pilots requires instruction in flight based on instruments and recovery from unusual attitudes, in which the flight instructor has the student close his eyes while the aircraft goes through a disorienting series of turns, climbs, and descents, then has the student return the airplane to straight-and-level flight. Military aviators, in addition to being subjected to periodic proficiency reviews, are required to attend, every five years, refresher courses in human physiology that include a section on spatial disorientation.

Rogers Shaw, a director at the FAA Civil Aeromedical Institute in Oklahoma City, admits that training exercises such as unusual-attitude recovery are limited by the fact that the student knows and expects to have to make a correction to return the airplane to straight-and-level flight. Spatial disorientation is so insidious, and the sensations it creates so compelling, that unless you suspect you have a problem, you would never know there is one. Unlike other airborne emergencies—an engine quitting, loss of electrical power, smoke in the cockpit—there's no principal event to indicate anything is wrong. If the pilot does realize something is not quite right, he may react too late, or in a way that aggravates the

LEFT: WYLE LABORATORIES; TOP: MARTIN LUTHER KING LIBRARY

Demonstrating the "spiral phenomenon" in the 1920s required blindfolds, a field near San Antonio, Texas, and an airplane from which to see the results. The blindfoldees were told to walk a straight line while pushing a chalk liner. They got off to a good start, but, deprived of a horizon, soon veered far off course.

situation. Or, as in the case of Major Young, the pilot may not react at all.

The crash of John F. Kennedy Jr. on the night of July 16, 1999, off the island of Martha's Vineyard, which killed him, his wife, and her sister, brought public attention to the consequences of spatial disorientation. The investigation of an air crash, says Richard Bunker of the Massachusetts Aeronautical Commission, who investigated the Kennedy crash for the state, is a process of elimination. You start with the airplane. After eliminating structural or mechanical problems, you look at external factors, such as weather.

Then the investigation turns to the pilot. You examine his or her training and experience, medical history, personal life, and possible extenuating factors. Eventually, Bunker says, the evidence and the circumstances point to "well, maybe we're looking at spatial disorientation."

Kennedy did not have an instrument rating. He was flying at night over water with visibility as low as three miles in haze, meaning there were few lights and no visual horizon for reference. About 10 miles from Martha's Vineyard, he deviated from course and made a number of maneuvers suggesting he was lost or disoriented. The final radar track showed the airplane in a tightening right-hand turn—called a graveyard spiral—that reached a descent rate exceeding 4,700 feet per minute before the airplane hit the water.

In the case of Major Young, it was all over in less than a minute.

Young, call sign Grumpy One, flew the lead aircraft in a formation of two F-15s in a combat exercise against two F/A-18s over the Pacific Ocean, about 50 miles west of Cape Arch, Oregon. The visibility was 10 miles or greater, with the horizon discernible in all directions.

While Young's wingman, Lieutenant Colonel Paul Fitzgerald, call sign Grumpy Two, engaged the two F/A-18s, Cowboy One and Two, Young began a climbing right turn that peaked at 18,800 feet, then began descending in the direction of his wingman and the other two aircraft.

As he did so, Cowboy Two, having maneuvered into position behind Grumpy Two, radioed over a common frequency monitored by all the pilots that he had "killed" one of the two F-15s.

By now, Young's descent rate had nearly doubled, to 30,000 feet per minute, and he was nearing 5,000 feet—a floor set for the exercise to allow for a margin of safety; at that altitude, Young should have broken off the engagement.

Eight seconds later, Young's airplane hit the water. Young's wingman told investigators that all he saw was "a big white splash that reminded me of Niagara Falls."

Young's remains were recovered along with some of the wreckage, the pieces of which were no larger than "a small trash can," in the words of the accident report. With the airplane almost completely destroyed, analysis of the engine and airframe was limited to a review of maintenance records and interviews with ground personnel. These things, along with the fact that Young had never indicated a problem and the airplane had performed as expected, strongly suggested that the problem was not mechanical. (Coincidentally, a few months after Young's crash, a Missouri Air National Guard F-15C broke apart in flight, setting off a fleet-wide grounding of F-15s to investigate failing longerons.)

With the airplane's flight data recorder also destroyed, investigators were limited to reconstructing the flight path using radar tracking data, videotapes of the other airplanes' head-up displays (which project critical flight information on a transparent display above the instrument panel), and data from their flight recorders, in addition to the testimony of the other pilots. Investigators determined that Young's airplane hit the water at an angle of 24 degrees at a speed of 630 mph.

WYLE LABORATORIES (2)

The report says that Young's helmet showed he was sitting head-up, indicating he was likely conscious at the time of impact. Analysis further suggested Young was looking up and slightly to the right, not at the ocean in front of him, at his head-up display, or at his instruments. His G-suit was not fully inflated, indicating that he was not pulling significant Gs to arrest his descent.

Increasingly, the evidence pointed to spatial disorientation.

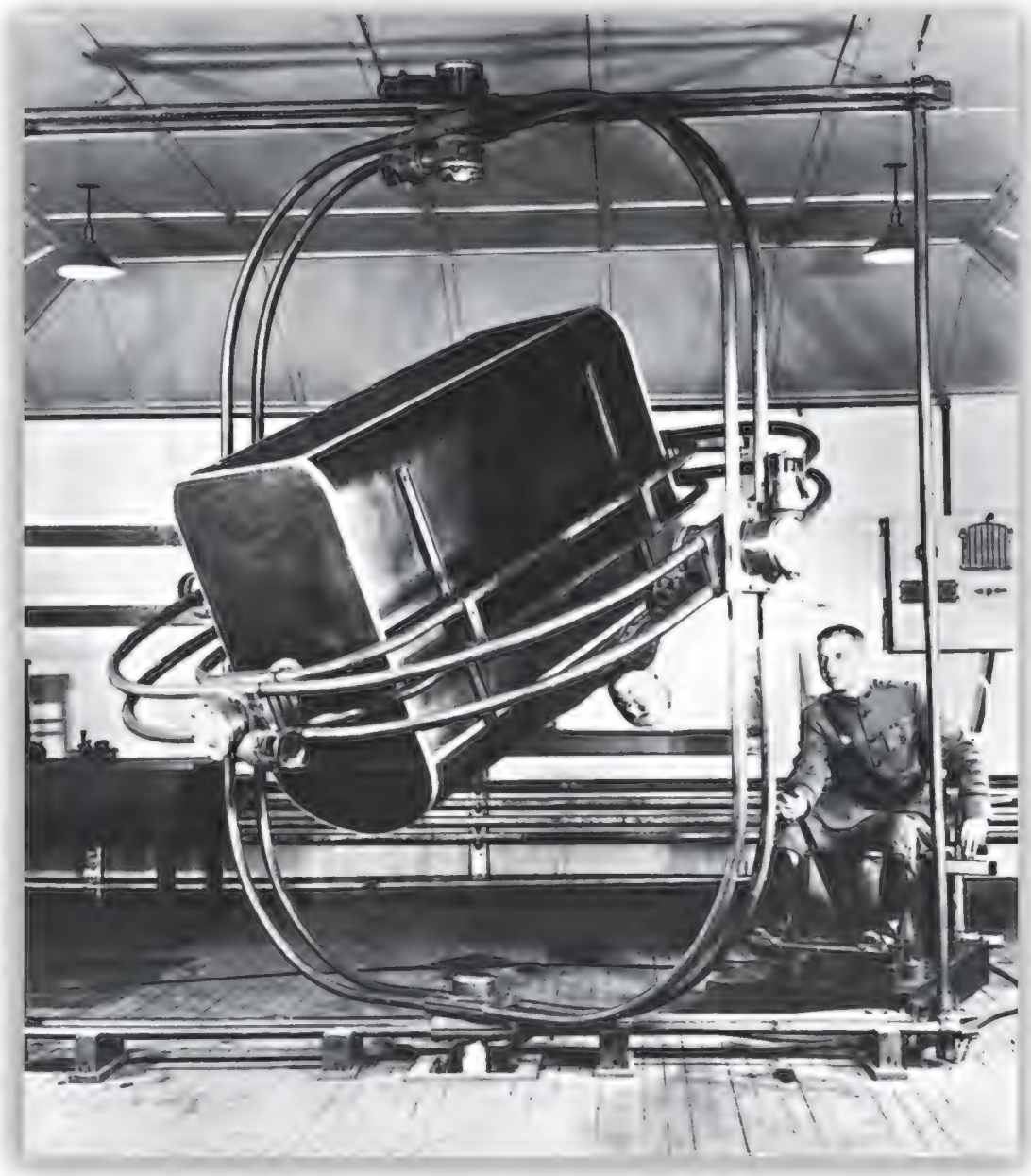
As Young went from climb to descent in his final maneuver, he would have been susceptible to a somatogravic illusion making his dive angle seem much shallower than it actually was. He may, in fact, have thought he was inverted. The fact that his rate of descent increased significantly in the final seconds indicates that Young "may have even believed he was climbing in the final moments, although he was actually still descending," the investigators' report said.

In addition to primary flight data (attitude, airspeed, altitude, heading), the head-up displays in military cockpits provide the pilot a continuous view of what is directly in front of the aircraft. Displays also project flight information on the helmet visor so the pilot's head is free to move. Three-dimensional "highway in the sky" displays give a pilot's-eye view of the terrain and project a path to follow. Today's pilots can maintain a level of situational awareness that their predecessors never dreamed of.

But when it comes to countering spatial disorientation, the new displays create their own problems, says Bill Ercoline, a scientist at California-based Wyle Laboratories who provides human factors research for the Air Force Research Laboratory at Brooks City-Base in Texas. Studies of unusual attitude recovery using head-up displays found that HUDs can actually interfere with recovery. The field of view is narrow, the manufacturers use symbols that are not universal, and the nature of the displays is not intuitive; compounding all that, there's simply too much information to process. "It's like drinking through a fire hose—it's just difficult to get the right gulp," Ercoline says. With so many more systems to manage and monitor, pilots end up devoting less time to actually flying.

The Air Force commissioned a team, led by NASA and the Air Force Research Laboratory at Ohio's Wright-Patterson Air Force Base, to develop an autopilot that engages when the pilot is unconscious or unaware that he is about to hit the ground. The Automatic Ground Collision Avoidance System—Auto-GCAS—evaluates a variety of factors (aircraft weight and performance, navigational information, terrain and elevation data) to constantly calculate the aircraft's position, time before impact, and maneuver required to prevent an impact. When the system determines that the airplane is within 1.5 seconds of the point of no return and the pilot still has taken no action, it will take control and perform an automatic rescue maneuver. The system, developed and tested over the past two decades, is now ready for use with F-16 and F-22 fighters. The Department of Defense hopes the system will virtually eliminate "controlled flight into terrain" crashes due to spatial disorientation or G-induced loss of consciousness.

While Auto-GCAS will certainly help, says William Albery, a senior scientist at Wright-Patterson, it won't completely eliminate spatial disorientation. Susceptibility to vertigo will continue, he says, as long as there are human pilots on airplanes, and even pilots not in airplanes—in several incidents, pilots who remotely fly aircraft have lost control due to vertigo. The only way to completely eliminate the problem, he says, is to develop fully automated aircraft.



TOPICAL PRESS AGENCY/GETTY IMAGES

A fiendish device of the late 1920s, the Ruggles Orientator could rotate a student in any of three axes. It was said to be useful for "developing and training the functions of the semi-circular [ear] canals and...training aviators to accustom themselves to any possible position in which they may be moved."

Big Idea

MEGALIFTERS PROVE YOU'RE NEVER TOO FAT TO FLY.

BY KARA PLATONI

NASA'S SUPER GUPPY TURBINE looks like it should be impossible to fly, or at the very least, like it should bumble about the heavens and then clatter to Earth the minute gravity figures out it's up there. It weighs 50 tons. It is an airplane big enough to swallow other airplanes—a hangar with wings. But when pilots Rick Hull and Terry Pappas bring the Guppy in for a landing at NASA's Marshall Space Flight Center in Huntsville, Alabama, on a clear December morning, the airplane descends with the stately grace of a steamship cruising into harbor.

This Guppy is the last in a series of gargantuan cargo aircraft that have been wowing bystanders since 1962, when its grandmother, the Pregnant Guppy—at that time the world's largest airplane—did the heavy lifting that helped get NASA to the moon on time. Since then, NASA has used the Pregnant Guppy progeny to

"They'll never get off the ground," warned detractors of Aero Spacelines' Guppy series of colossal cargo airplanes.

JIM KOEPNICK

ferry equipment for Skylab and the International Space Station. Today, this Guppy is picking up a duplicate of the 10-foot-wide, 2,400-pound rotary joint that turns the solar panels on the space station; the original is malfunctioning, and astronauts and engineers in Houston will need the duplicate to devise a fix.

The Guppies also influenced a generation of airplanes designed for more terrestrial matters: Airbus Industrie's Beluga and Boeing's Dreamlifter carry aircraft subassemblies between plants in different countries. Pumped-up airplanes are rare—only one of eight Guppies built still flies, there are but five Belugas, and Boeing plans to build only four Dreamlifters. Their proof of principle, the Pregnant Guppy, is largely responsible for making good on President John F. Kennedy's 1961 promise to put a man on the moon "before this decade is out."

BOEING MEDIA (2)

Boeing's voluminous Dreamlifter – its cargo bay can hold some 80 Mini Cooper cars – plays a critical role in the production of the 787 Dreamliner, shuttling parts between Europe, Japan, and the United States.

The brainchild of Aero Spacelines partners Jack Conroy and Lee Mansdorf, the Pregnant Guppy was conceived to haul 40-foot-long Saturn S-IV-B rocket stages from California to Cape Canaveral, Florida. Previously, NASA had been shipping them through the Panama Canal, but the voyage was far too slow for a race to put a man on the moon by the end of the 1960s, and the long exposure to sea air put the stages at risk for corrosion.

NASA had toyed with a few other concepts, including piggybacking the rocket stages on an Air Force C-133 transport, or slinging them beneath a blimp. But these solutions weren't aerodynamic and still would have exposed sensitive parts to the elements. Conroy and Mansdorf had another idea: transform Mansdorf's stockpile of Boeing B-377 Stratocruisers, purchased just as the Jet Age was making the propeller-driven airplanes less desirable, into the U-Haul of the skies.

First, Aero Spacelines stretched a Stratocruiser fuselage by adding a 16-foot aft section. Then the engineers built a bigger fuselage atop it: More than 19 feet in diameter, it was braced to the original with lumber, to be cut away if the airplane survived test flights. Another key modification would later define the Pregnant Guppy: a tail section that had to be removed for cargo loading. The design necessitated disconnecting the flight control cables each time the tail was opened.

But there was a problem: Aero Spacelines had built the airplane without actually getting a NASA contract. As soon as the Guppy passed its air trials, surprising those who had predicted a fiery crash, the nearly broke Conroy set off in it for Huntsville to demonstrate his concept to Marshall's famous director, Wernher von Braun. The still-cautious Federal Aviation Agency gave Conroy special clearance, provided he didn't fly over cities.

Von Braun was so impressed he insisted on taking the Guppy for a spin, much to the alarm of his staffers, who pointed out that it was still held together with two-by-fours. Worse, the airplane, with a full load of fuel to simulate a full payload, was super-flammable. Nevertheless, once von Braun took the pilot's seat, the irrepressible Conroy secretly told the flight engineer to shut down the two portside engines—a sly demonstration of the airplane's power. When von Braun finally realized that he was flying comfortably on two engines, Conroy, according to legend, coolly responded, "Oh, we do that all the time to save fuel." (In fact, says Daren Savage, who runs a Web site called *AllAboutGuppys.com*, "Conroy was actually standing on the rudder so that von Braun didn't really know how much effort it was really taking to fly this plane.")

Aero Spacelines soon had its contract. The Pregnant Guppy promptly reduced

NASA's cross-country transit time from 18 days to 18 hours. "It enabled them to keep the schedule that they needed so they didn't have to scrub any launches," says Savage.

With proof that airplanes could safely be super-sized, NASA ordered an even bigger one. Dubbed the Super Guppy, it had a 141-foot-long body and 25-foot-wide fuselage. A hinged nose that could swing open 110 degrees for loading replaced the removable tail. In the meantime, Airbus, which manufactures aircraft components in France, Germany, Spain, and the United Kingdom, was also warming to the Guppy concept. In the early 1970s, Airbus began using four Super Guppy Turbines—a generation with Allison 501-D22C turboprop engines—to shuttle subassemblies internationally, saving time and eliminating bureaucratic hassles. (However, it also led to the taunt that every Airbus took its first flight on a Boeing.) "By using aircraft, you add flexibility to your industrial process," says Bruno Gutierres, head of new programs and development for Airbus' logistics and supply chain. "You are not dependent on weather conditions, for example, like you are with surface transports."

NASA

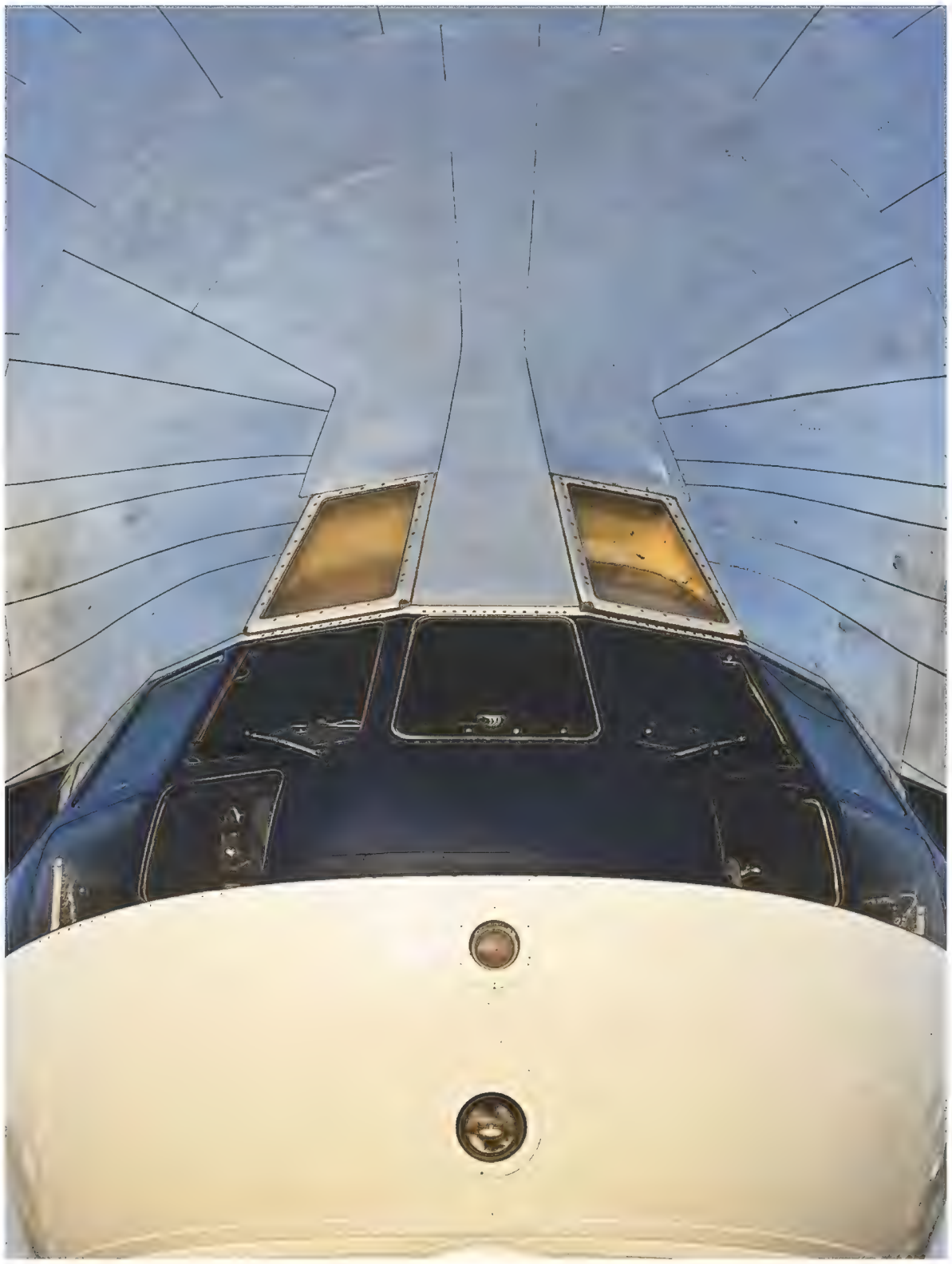
CLAY LACY AVIATION

Aero Spacelines' success (pilot Clay Lacy, left, with Jack Conroy) inspired Airbus to design the whale-like Beluga (below).

Despite producing two more airplanes in the 1970s—the shorter, fatter Mini Guppy and Mini Guppy Turbine—Aero Spacelines foundered, particularly after the Mini Guppy Turbine crashed in 1970, killing its crew. NASA retired its original Super Guppy in 1991, and the Pregnant Guppy was cut down for scrap; there were no replacement parts for these unique aircraft, and Aero Spacelines had long gone out of business. Besides, Airbus was manufacturing ever-bigger airplanes, and needed even bigger cargo haulers.

By 1997, Airbus parked three of its Super Guppies, and traded the youngest of its litter to NASA—the one the agency still uses today—in return for cargo room

FRED SEGGIE



RICHARD VANDERMEULEN

for the European Space Agency on the space shuttle. Airbus replaced the Guppies with a whale-like airplane of its own invention: the Beluga. A modification of the Airbus A300-600, the Beluga can carry more and fly faster and higher than the Guppy. Cargo is loaded onto the Beluga via a hatch above the nose that swings up; to make this possible, the cockpit was dropped 51 inches, giving the Beluga its distinctive pointy nose.

True workhorses, Airbus' five Belugas fly daily. "This aircraft is fully integrated into our industrial process and it's very reliable for us," says Gutierres. "This is something we are using day to day, something very important."

Boeing hopes to accomplish something similar with its Dreamlifter, the newest entry into the realm of jumbo airplanes. It will shuttle parts of the company's new 787 Dreamliner between Italy, Japan, and three U.S. cities, compressing shipping time for components previously routed via rail or sea from 30 days to one. Based on the Boeing 747-400, the Dreamlifter somewhat resembles an overinflated toothpaste tube, with the cockpit where the nozzle would be; when it debuted in 2006 still coated in green primer, bystanders likened it to a flying pickle. (Boeing Commercial Airplanes president Scott Carson reportedly joked to Joe Sutter, chief project engineer for the original 747, "Sorry for what we did to your plane.") The 787 components are loaded through a swing tail with the world's largest cargo loader.

Perhaps because of the difficulties Boeing has had with its related Dreamliner program, the company declined to let staff associated with the Dreamlifter give interviews for this article. (The 787's delivery has been delayed by supply chain problems, according to news reports, and last year the program's general manager was replaced.) However, the airplane's specs alone tell an impressive story: The Dreamlifter is the first monster hauler designed to cross oceanic distances—it can fly 7,000 miles without refueling. Although NASA's Super Guppy Turbine still claims the title of fattest airplane, the Dreamlifter is the most voluminous; according to the company's magazine, *Boeing Frontiers*, it's big enough to engulf a three-level, 10-lane bowling alley.

But, well—how do these enormous airplanes fly?

EMMETT L. GIVEN

Four KC-97 Stratotanker airframes were cannibalized to build the Super Guppy (right); the Guppy's distinctive aluminum fuselage sheeting was overlapped, much like roof shingles, when attached to the bulkheads (above).

LARRY GLENN (2)

Flight engineer Larry Glenn (left) gets a watery sendoff after his last Guppy mission; crew members Rick Hull and Terry Pappas (above) joke that they keep a road atlas on hand so they can follow the interstates.

NASA's Super Guppy crew members hear this question so often that most of the time, they just shrug good-naturedly and say that they drove in on the highway. When pressed, they'll admit the big airplane actually feels quite small. "It's not like flying with a house on your back," says Frank Marlow, who has piloted Guppies for NASA since 1979. "It is really very clean and very nice."

In fact, says Beluga pilot François Cantin, pilots of that aircraft get the opposite impression, thanks to the Beluga's lowered cockpit. "When you are seated in the front of the aircraft, it seems that you are flying almost a small aircraft, because you are quite close to the ground," he notes. Pilots can barely see the wingtips, much less the plane's bulk, he says. "It's really when you leave the cockpit that you notice at once that you are really in an incredible airplane."

Unless a crosswind hits you.

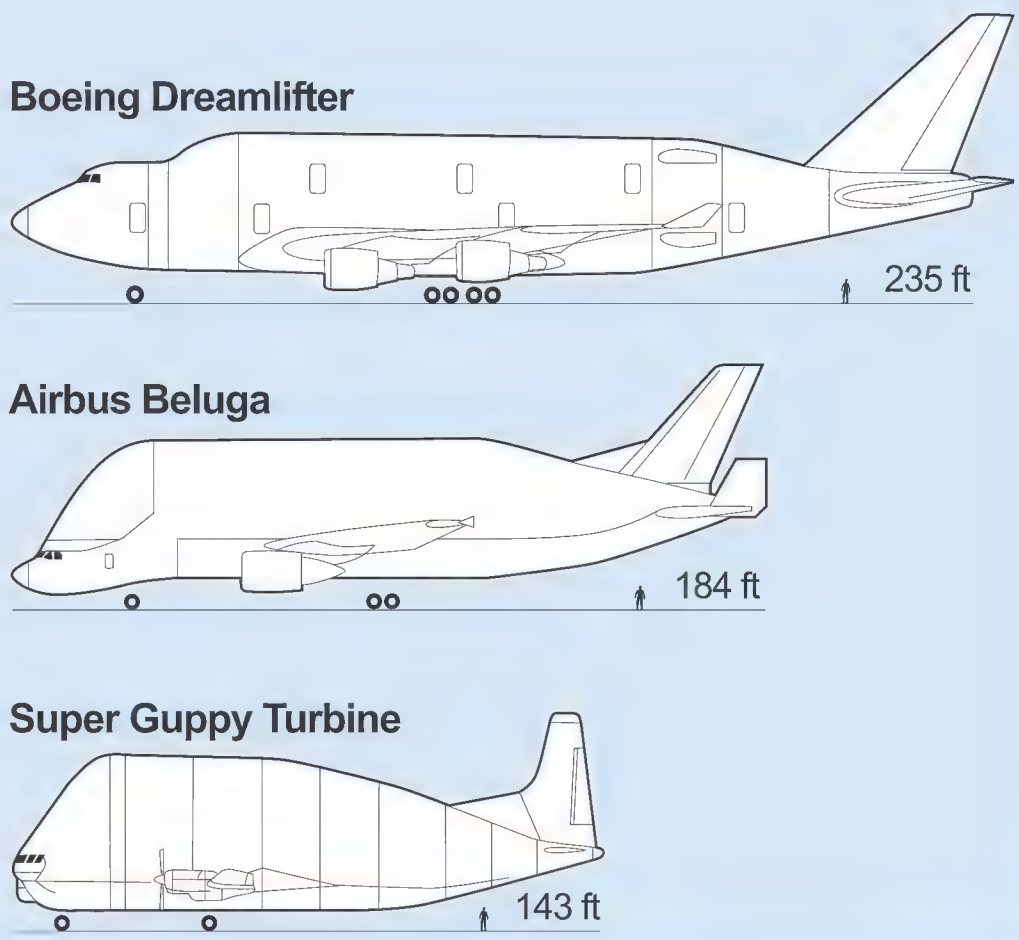
"In this aircraft, you can feel it move laterally in turbulence, and no other aircraft behaves like that," says Cantin. It's like the sideways push you feel when driving a car over a bridge during a storm, he says. Crosswinds make landing the Super Guppy very difficult, adds pilot Terry Pappas. "Because it's such a huge surface, a strong crosswind generates a tremendous amount of force on it—it wants to turn the tail downwind and it makes the nose point into the wind," he explains. "That's what you call weathervaning. Well, once you get that tendency going, it's very difficult to counteract. You've got this rudder that you can use to help you counteract it, but if you're a half-second late getting that control surface displaced, now you've got this huge 140,000-pound [with payload] machine already starting to rotate into the wind and it's hard to stop."

But those are about the only similarities between these two enormous airplanes. The Beluga is a modern jet airplane; the Super Guppy is a dinosaur. It's a four-engine turboprop and all-manual, with no autopilot and no hydraulics except for the nosewheel steering, the brakes, and the windshield wipers. "It's old-style flying," says pilot Rick Hull. "You don't take off and as soon as the

Profiles in Bulk

MAXIMUM TAKEOFF WEIGHTS OF MEGALIFTERS

Boeing Dreamlifter	803,000 lbs.
Airbus Beluga	342,000 lbs.
Super Guppy Turbine	170,000 lbs.



JUAN THOMASSIE

gears are up and the flaps up, the autopilot's on and you're talking about what's going on on Wall Street." The Guppy prefers to fly out of trim and requires, let's say, a certain degree of watchfulness. "It's like going in a china store with a three-year-old," says Hull. "You can turn your back on it for about two or three minutes, but you're not going to like what he's doing, you know?"

It's also one of the few airplanes that still fly with a nine-person crew. Two flight engineers, two loadmasters, and three mechanics must disconnect the control cables, manually unbolt the nose before it can be swung open, carefully situate the payload, and pack the cargo into the Guppy's special 16,000-pound shipping fixture. This half-pipe-shaped fixture, which rolls in on rails, mimics the cargo bay of the space shuttle and holds the payload steady. Since the hold is not pressurized or climate controlled, sensitive cargo can be protected by a lid that forms an immense silver cylinder—one, the crew notes, resembling a giant beer can.

While the Beluga flies constantly, the Super Guppy flies maybe a half-dozen missions a year—but they're each about a week long, and include several stops. The long hauls, as well as the old-fashioned flying style, make the Guppy crew a very close team. Pilots still call out commands to flight engineers, an unusual exercise in thinking ahead for pilots accustomed to flying two-seaters. As Pappas puts it, it's like driving a car while having the passenger shift the gears. "We're kind of like a concert duo," says flight engineer Larry Glenn, who has been flying NASA Guppies since 1987.

The Beluga, by comparison, flies with a three-person crew—two pilots and a flight engineer. Another key difference: while Cantin says the Beluga's size affects speed and climb rate only minimally, the Super Guppy flies so low and slow that, as Hull puts it, "you feel like you're riding in the Goodyear blimp"—an impression aided by the roomy cockpit, the panoramic windows, and the fact that most of the crew ride seated around tables, at which they often share sandwiches and a cooler of drinks. "We're so slow that birds attack us from the rear," deadpans Glenn. "I mean, we've got semis that pass us on the freeway." Crew members swear they keep a road atlas on the flight deck so they can follow the interstates.

Traveling in today's Super Guppy is a cakewalk compared to flying the original, which lacked such niceties as a pressurized cockpit. "Any time we went above 10,000 [feet]—and we did it a lot—everybody was on oxygen. We looked like a bunch of British fighter pilots," Marlow recalls with a laugh. It had such a long nosegear that on takeoff the wing faced the oncoming air at an angle that generated lift very early. The result was the unnerving tendency for the main landing gear to lift off first, and the nose last, so the aircraft went trundling down the runway like a wheelbarrow. (The current airplane instead has a Boeing 707 nosegear installed backward, and pilots aim for a three-point landing.)

ANDY MARTIN/AIRTEAMIMAGES.COM

Because Guppies are so novel, the flight crew occasionally faces hair-raising unknowns. Dan Hill, a flight engineer on the original Super Guppy from 1979 to 1991, recalls that the crew sometimes had to guess how much power the Guppy needed to get off short runways: "We never really knew, because of the lack of testing that was done, how safe it was to go to certain power settings. So we had one that was called 'Fear Setting.' At 1,000 feet

Airbus' Beluga (left) ferries everything from space station components to priceless artwork. The 57-foot-long V-22 Osprey fits easily in the Super Guppy's cargo bay (above).

LARRY GLENN

we'd always do a runway remaining check, and that's when we determined if we needed 'Fear Power.' "

Marlow, who has survived so many misadventures that his colleagues whisper "God loves Frank" in hushed tones, recalls a mission to retrieve a NASA T-38 trainer that, struck by lighting, had had a fuel tank blown open. Although the smaller airplane was supposed to have been defueled, 50 gallons of gas sloshed out after takeoff, creating heavy fumes and a serious risk of explosion for the Guppy. The flight crew got ready for an emergency landing—then realized that if they lowered the electrically powered landing flaps,

ARNOLD GREENWELL

The star attraction at the 2000 fly-in at Oshkosh, Wisconsin, the Super Guppy draws crowds wherever it goes.

they risked creating a spark that could immolate their airplane.

They'd have to try a no-flap landing, but as the runway approached, Marlow realized another problem: "We were going fast and we had never made a no-flap landing in the airplane. We never practiced it. None of our training had it!" As the flight engineer desperately looked through charts for the no-flap stall speed for their aircraft's current weight, Marlow knew he'd have to guess. "We were 165 knots and I said 'This feels good,' " Marlow recalls. Luckily, he'd intuitively picked just the right speed. After making a safe landing, he double-checked: The magic number was 165.

The original Super Guppy's most famous lucky break happened in 1965: While it was doing a high-speed dive during its certification test, the force punched a 23-foot hole into the airplane's domed forehead. The airplane would surely have blown apart, had small access doors at the back of the airplane not popped out, releasing the additional pressure. "For seventeen very long minutes on September 25, 1965, the Super Guppy's future looked uncertain, indeed," the pilot, Lieutenant Colonel P.G. Smith, recalled in an article he penned for *Air Force* magazine. "But who could now say that she is not—quite literally—a great airplane?"

Even though they're often unflatteringly compared to hippos and elephants and the Oscar Mayer Wienermobile, the Guppy, Beluga, and Dreamlifter all draw crowds wherever they land. Gutierres recalls listening to the radio on the way to an Australian airport to meet up with the Beluga, when suddenly, he says, "they stopped the program and the guy said, 'I just saw an incredible aircraft!' " Even aviation professionals do double-takes. "We always get comments from air traffic control—'*What kind of airplane is that?*' " says Glenn.

On that clear December day in Huntsville, Glenn stands inside the Super Guppy's cargo bay, watching the payload slide in. He turns toward the rear of the airplane and unzips the flap that covers the tail section, pointing to a part of the lower fuselage. It came from the Pregnant Guppy, he explains—by the time this Guppy was built, there weren't any other parts available, so this piece of its forebear was used. It's sort of the alpha and omega of Guppy history, he says.

This happens to be Glenn's last mission; he's retiring after 42 years of flight. But the Super Guppy will fly on, in a program that will bring the history of NASA's megaplanes full circle. The Super Guppy will soon begin hauling the Ares rocket, the Orion Crew Exploration Vehicle, and other oversize parts for the Constellation program, which will take U.S. astronauts back to the moon.

Control

ON THE GROUND WITH MARINES IN AFGHANISTAN, THE AUTHOR SEES

A FAMILIAR VOICE GREETS ME from the shadows of an earthen barrier in Watapor Village, a few miles west of Pakistan in Afghanistan's mountainous Kunar Province. "What brings you out to this neck of the woods?" asks Marine Captain Zach Rashman. Fresh off the back of a troop transport, I join Rashman behind the barrier to escape the sun as we await a nighttime convoy. We're headed to Camp Blessing, a military base about the size of a small city park; the Marines call it "The Edge of the Empire." From this outpost, a platoon from the Second Battalion, Third Marine Regiment has been trying to ensure stability in the area by befriending villagers and flushing out enemy militias. Some of their adversaries may have fought for the Taliban, others for al Qaeda; others are on their own. U.S. intelligence officers have identified 22 different groups of bad guys in the province.

Now in October 2005, the platoon is preparing for Operation Valdez, named in honor of Lance Corporal Steven Valdez, a Marine killed at the base by a mortar lobbed from a nearby ridge. The purpose of the mission is to locate the spot from which that mortar was launched and record its coordinates in order to rapidly return fire should the position be used for another attack.

I had met Rashman six months ago, and 8,000 miles away, when he was a first lieutenant and 15 pounds heavier. At a live-fire training area outside Twentynine Palms, California, I watched him rehearse the job he's here to do as a forward air controller: guide weapons from aircraft to the precise spot where ground forces need them. In answer to his question, I came to Afghanistan, embedded with the Second Battalion, to observe how the often misunderstood mission of close air support is conducted. Having seen how Marines train for it, I'll be able to see if the training matches what is required in combat. Rashman, a 26-year-old CH-53D helicopter pilot who had just recently volunteered for a tour to work side by side with infantry, is able to point out almost immediately one big difference. "What you saw at Twentynine Palms six months ago was all USMC," he says, "Marine Air, Marine infantry, Marine artillery—Marine everything. It's all joint here. Local Afghan forces roll with Ma-

the Air

A DIFFERENT SIDE OF CLOSE AIR SUPPORT.

Story and photographs by Ed Darack

At a Marine base in California, a forward air controller, or FAC (opposite), trains for combat. In Afghanistan (above), Marines and Afghan forces patrol under cover of an AH-64 Apache.

rine grunts. We get lifted by Army Chinooks. Air Force A-10s provide fixed wing. Higher [command] even pushes us special operations AC-130s every now and again, and there is usually a Predator buzzing around somewhere."

A day after my arrival, I'm accompanying the platoon as they deploy from the base to destroy cave complexes near the mortar position where the enemy could hide. This will be my first combat experience involving CAS—pronounced "cass" in military circles—and I tap my fingers nervously on the ceramic plates of my body armor. As the order to move to the landing zone is given, I see Rashman running for a combat operations center instead of the waiting helicopters.

"Aren't you coming?" I ask.

"I'm stayin' in the rear for this one," he says.

"We got air, don't we?" I practically cry, and I flash back on a prediction Rashman made a day or two prior: that in combat I would understand the urgency of wanting every form of supporting fire available. I understand already, and I haven't even left the base.

"Type-3 control, brother," he responds, indicating that he, as a controller, will grant aircraft permission to engage on their own as long as the strike fits a series of parameters, including where and when they plan to drop ordnance. "I have to stay behind to act as not only the forward air controller, but to deconflict [separate airplanes from one another and from munitions] and deal with other types of air in addition to CAS, all that good stuff.... You'll be fine, just keep your head down."

I hurry to catch the 20 Marines quietly marching away and reach the helicopter landing zone just as two Army CH-47 Chinooks, accompanied by two Army AH-64 Apache gunships, appear in the distance. My minder, First Lieutenant Patrick Kinser, explains the plan to me as Camp Blessing's mortar crews launch a barrage of 120-mm rounds at a ridge protruding high above the fire-

base. Textbook close air support missions start this way—"suppression of enemy air defenses," the military calls it—to keep the aircraft called in for an attack from being attacked themselves.

"The birds'll lift us and we'll head down valley, as if we're on a routine flight, but then we'll bank hard and come in for a surprise attack," he continues. "Apaches will fly cover for us, then do close air support, if necessary."

Sensing my anxiety, the 24-year-old lieutenant adds, "A-10s are rippin' up here right now for CAS work, Rashman's already got 'em cleared. Hope you get to see some gun runs. You haven't lived till you've seen an A-10 hit a position with that 30-mm rotary gun. And tighten your helmet. Looks loose."

The Chinooks roar onto the dirt landing strip as the Apaches carve broad arcs overhead, keeping watch for enemy movement. Twenty Marines and 20 local Afghan Security Forces personnel load a week's worth of food and bottled water, then themselves, into the big helicopters. The engines spin up, and we lift away from the firebase.

A FAC confers with his radio operator in the Hindu Kush (left). After takeoff from Arizona's Marine Corps Air Station Yuma, a UH-1N Huey pilot releases flares and banks into a simulated attack run over the Chocolate Mountains in California (below).

Like Clockwork

Almost every Marine headed to Afghanistan or Iraq stops first at Twentynine Palms, the Marine Corps Air Ground Combat Center in California's Mojave Desert, for roughly 30 days of combat training. Six

Before heading into Afghanistan on an October 2006 close air support mission, a Navy F/A-18C from the USS *Enterprise* tests its countermeasure flare.

LT PETER SCHEU/DOD

months before Operation Valdez, I'm there too, crouching next to Zach Rashman as he eyes a target a half-mile distant, near the bottom of a gently sloping desert bowl. The Second Battalion, Third Marine regiment, based out of Kaneohe Bay, Hawaii, is in the second week of a pre-deployment workup. Under the intense supervision of "Coyotes," a select group who teach, oversee, and maintain the safety of visiting exercise forces, the battalion is preparing to assault a target—a cluster of dilapidated tank hulks—in a live-fire training exercise. As a forward air controller, Rashman is one of three Marines who will be directing the fire.

A Marine battalion can call on mortars, artillery, and aircraft, and each of the three kinds of fire is typically provided by operators who cannot see their targets. Instead, forward observers act as eyes for the weapons operators. Observers for each of the three forms make up the battalion's fire support team, or FiST, and coordinate their respective "fires" for the maximum destructive power and psychological impact.

Rashman and the other members of the FiST mark their maps and check and re-check their radios in preparation for the fury they will soon be directing onto the targets.

"This is a combined, simultaneous live-fire event; we design the training to be as close to the real thing as possible," says Lieutenant Colonel Doug Pasnik, my guide for the day. Pasnik, an F/A-18D Navy flight officer and a veteran of dozens of recent close air support missions in Iraq, runs the air support component of the day's exercise.

On the rocky knoll where the fire support team works, we hear the first rumbling booms of distant artillery pieces; 155-mm shells thunder into the target area seconds later, sending plumes of earth into the sky. UH-1 Huey and AH-1 Cobra gunships crest a distant ridge and assume a holding pattern, awaiting targeting instructions from Rashman. Coordinates blare from Coyotes' radios and members of the FiST shout back and forth, sometimes peering through binoculars, sometimes noting positions on the backs of their hands.

"Rashman will be doing Type 1 control, meaning he sees both the target and the attacking aircraft," Pasnik says, holding a radio set in each hand. Type 2 control means the ground controller is able to see either the target or the aircraft, or neither, if he has an observer who can see the target. Type 3 is similar to Type 2, except that the controller doesn't clear a strike for each release; instead, he clears the aircraft to engage for a period of time and within a limited area.

"Got 'em—eyes on the Hornets!" shouts a member of the FiST as he thrusts his index finger high into the air. Two F/A-18C Hornets streak across the powder blue sky. Smoke 21, the lead Hornet pilot, checks in with Rashman.

"One of the most difficult—and important—aspects of controlling air is deconflicting with other aircraft and fires," Pasnik explains as the Hornets disappear into the distance. "You have to ensure that your aircraft won't be in danger of getting hit by an artillery or mortar shell—or another jet or helicopter."

Infantry, packed into swift-moving armored personnel carriers, push into my field of view as artillery-lobbed "white star cluster" rounds burst over the target, showering it with burning phosphorus and marking it for the air strikes to come.

"Okay," Pasnik updates me, "Rashman's worked the Hornets into the fire support plan; the pilots have told him how long they'll be on station and what they're carrying. He's deconflicted the other fires; they'll be shutting down just before the

NATIONAL MUSEUM OF THE US AIR FORCE

Probably the best U.S. ground attack aircraft in World War II, the P-47D carried eight guns and, on some models, rocket launchers.

A Little Help From Above

ALTHOUGH THE FIRST close air support sorties were flown in the Italo-Turkish war of 1911-1912, World War I began without a formal doctrine for using aircraft to support troops on the ground. That was remedied by France in April 1916, when it became the first country to codify the mission.

The most famous U.S. display of the mission's effectiveness was made in the summer of 1944, when General George Patton's Third Army raced toward Germany through France. As Patton's tanks advanced, the P-51 Mustangs and P-47 Thunderbolts of the XIX Tactical Air Command, led by General O.P. Weyland Jr., flew in front of them and struck opposing tanks, blew up tank barriers, and strafed troops, trucks, and gun emplacements. Control of the pilots in the air came not from trained infantry on the ground, but from P-51 and P-47 pilots stationed at the head of the advancing tank columns. The position of air liaison officer, as Weyland called the pilot directing the air strikes, was a coveted one: Pilots took pride in helping their airborne brethren get weapons squarely on the target. The speed of Weyland's air strikes overcame an Army belief that aircraft should be used only when artillery couldn't reach.

In that campaign, the performance of the Republic P-47D Thunderbolt, with eight .50-caliber machine guns and the capacity for 2,500 pounds of bombs, reinforced the idea (introduced by a German aircraft in World War I, the Halberstadt CL II) that an aircraft could be designed and produced specifically for close air support. The Jug, as its pilots called it, could also survive severe damage from ground fire to get its pilots home.

The years following World War II were fraught with disagreement among the U.S. military branches over CAS, particularly between the Army and the newly formed Air Force. With responsibilities for all types of air missions — strategic bombing, interdiction (damaging the enemy's military potential before it can be brought to bear), and transport, as well as close air support — the Air Force began to concentrate its resources on striking the enemy from afar. The Army argued that it needed more control over U.S. Air Force aircraft to help its infantry maneuver because there were still ground wars to fight.

The services disagreed more fervently over priorities for air power at the outbreak of the Korean War than at any other time. The decision in Korea to place Marine Corps air operations under the command of the Air Force exacerbated the discord, but the war also produced another storied demonstration of close air support. As the First Marine Division withdrew fighting from the Chosin Reservoir in the winter of 1950, Marine F4U Corsairs flew day and night, using napalm, gun runs, and rocket attacks to keep the Chinese army hunkered down.

Long into the cold war, the strategic nuclear mission remained the Department of Defense's air priority. But experience on the ground in the Vietnam War, which began without a joint Army-Air Force doctrine of close air support, ushered in new ideas and capabilities for CAS. Two Marine Corps aviators proposed a dedicated forward air controller aircraft, which became the OV-10 Bronco, used by all services. An Air Force captain pushed the development of the side-firing gunship (initially developed for camp perimeter defense, this platform would evolve into one of the deadliest CAS platforms available). The gunship became the AC-130, flown today by special operations crews. And new policies allowed commanders in all services to plan and coordinate air operations with other military branches.

After the strategic air power successes of Operation Desert Storm, debates over the priorities of air missions have continued. The challenge for the air services now is how best to use air power in places like Afghanistan and Iraq, where typically the enemy forces are not concentrated but dispersed and sometimes impossible to find.

For more about P-47s in WWII, read an excerpt from Hell Hawks! *by Robert F. Dorr and Thomas D. Jones (Zenith Press, 2008) on* www.airspacemag.com.

jets are inbound. He's holding the two gunships off laterally, for employment later."

As Pasnik refocuses his attention on one of his radios, pieces of this seemingly chaotic puzzle click together for me. In order to transmit all relevant information to an attacking aircraft, ground controllers use a standardized set of instructions, the "Nine-Line Brief." The brief details the nine points of information required by pilots tasked with close air support, including target descriptions and locations of enemies and friendlies. Once an aviator reads the information back, the ground controller will issue the "cleared hot" call, granting permission to release ordnance.

Just as Rashman completes his brief, Smoke 21 rolls in; the pilot immediately confirms the information. Rashman's voice booms out of the Coyotes' monitoring radios: "Cleared hot."

Smoke 21 dives and the roar of twin jet engines reverberates in my chest. A hundred-yard wall of roiling fire vaults skyward as six 500-pound, Mk82 bombs slam into the ground. Smoke 21 banks hard away from the conflagration—and barrel rolls. The FiST erupts in cheers. The rattle of .50-caliber machine gun fire resonates from tanks that have taken positions in the hills around the target, 81-mm mortars begin slamming the target anew, and the infantry swarms over its goal.

"That," Pasnik says, "is how CAS is done."

The Chaos of Anaconda

By all accounts, one of the great successes of the war in Afghanistan was an unprecedented coordination of air power with special operations forces on the ground, who accompanied Northern Alliance fighters and designated enemy targets for air strikes. But when the military leaders of the Afghanistan campaigns attempted to combine special operations with conventional forces for large, coordinated missions, there were also failures.

Among the most visible breakdowns—and the most analyzed—was the confusion that jeopardized Operation Anaconda in March 2002. Planned to trap al Qaeda and Taliban fighters who had slipped away from the December 2001 battles in Tora Bora and who were hiding in eastern Afghanistan, Operation Anaconda was a weeks-long battle in mountainous terrain. It had been planned months earlier and always with the expectation of close air support, but no notification had been given to air commanders until five days before the battle began, and no system was in place to manage and integrate close air support requests.

The night before the battle began, Air Force Major Scott "Muck" Campbell and Lieutenant Colonel Eddie "K9" Kostelnik had been called out of their base in Kuwait and were the first A-10 Thunderbolt II pilots on the scene in the Shahi Kot Valley.

"Nobody knew where anybody was," says Campbell. "Nobody was deconflicting. The biggest threat was us running into each other, not the bad guys shooting at us." Campbell describes pulling off of a gun run only to find himself just a few hundred yards off the nose of an AC-130. At one point, a Navy F/A-18 rocketed between his wingman's aircraft and his own. "K9 and I were getting 'talked on' to a target and a JDAM [Joint Direct Attack Munition] goes off directly below us, and we're like 'Where'd that come from?' It was completely out of control," says Campbell. "A mortar would impact and we'd literally have a crowd [of friendly ground troops] calling in."

It wasn't that the air controllers and pilots weren't speaking the same language. The military has made certain that training in every service is based on the same set of protocols. "The air controller course I went through is virtually identical to those of other branches," says Rashman. "Upon graduation we're all Joint Terminal Attack Controllers—JTACs."

The problem in Anaconda came from the mission's planning staff. In a study of joint operations conducted for the Naval

The F-15E Strike Eagles of the 336th Expeditionary Fighter Squadron flew close air support (with A-10s and B-52s) for an April 2006 operation in Afghanistan.

MASTER SGT LANCE CHEUNG/USAF

MASTER SGT LANCE CHEUNG/USAF

Heir to the P-47, the A-10 Thunderbolt II (left and top) is a purpose-built CAS aircraft, one of many types Marine FAC Zach Rashman (above) can call on in a jam.

War College, Marine Colonel Norman Cooling blames the disarray during the battle on the failure to integrate command. Special operations forces in the area reported to U.S. Central Command instead of to Army Major General Franklin Hagenback, the joint task force commander to whom all other participants in the battle reported. "Failures in integrated planning and intelligence sharing produced highly publicized fratricide incidents and situations such as that on 'Roberts' Ridge' where a Ranger Quick Reaction Force inserted into a known enemy kill zone," Cooling wrote. (In the Roberts' Ridge incident, Navy Petty Officer First Class Neil Roberts was killed by enemy gunfire. Six more Americans died trying to rescue him.)

Military leaders analyzed the deficiencies in integrating air power with ground forces and proposed twin corrections: First, insist on unity of command. In Afghanistan, two different commands, one controlling special forces, the other controlling conventional forces, had produced an us-and-them culture, similar to the division that had characterized the Army and Air Force approaches to air power since the services separated in 1947 (see "A Little Help From Above," p. 56). Second, make close air support a part of the original battle plan instead of an emergency call. "We need to quit using CAS to save lives and start using it to win battles," says Colonel John Allison, former chief of the close attack branch in the Air Force joint air-ground division, tasked with integrating ground and air operations. "We have grown an entire generation of Army officers who think there will always be airplanes overhead. It is an airpower buffet, hot and ready 24/7. You get hungry and go eat—no planning required. The Air Force is quite good at doing close air support...but if the Army doesn't incorporate air into its maneuver and fire plans from the beginning, it will always be the 911 call."

Combat CAS

On Operation Valdez, the mission runs as smoothly as the training I witnessed at Twentynine Palms. The two Chinooks land side by side and lower their loading ramps on a flat, grassy section of the target ridge. Motivated by a stiff tug by Corporal Justin Bradley, a 6-foot-5, 270-pound squad leader, I bolt down the loading ramp and immediately gaze skyward to see one of the most soothing views of my life—Apaches roving the airspace high above nearby ridgelines and A-10s soaring above them.

"Show-of-force CAS!" Bradley yells over the shriek of the Chinooks' engines. "Just

TECH SGT JEFF WALSTON/USAF

the sound of those A-10s keeps the bad guys down. Everybody says the A-10s are ugly. Betcha never seen such a beautiful sight in your life though."

They are a reassuring sight, but I don't gaze upward long. I'm busy finding a rock to take cover behind.

Apaches, A-10s, and even an AC-130 gunship (at night) fly support missions throughout the next four days—never firing, but remaining on station and ready to provide support at a moment's notice as the Marines run patrols, looking for the mortar position. The roar of the Warthogs and the whine of lower flying Apaches echo through the steep valleys of the Hindu Kush. Throughout the operation, our interpreters and attached Afghan fighters pick up Taliban radio chatter and alert us of impending ambushes. But none comes. During a day patrol led by Bradley, the Marines on his squad discover signs of a mortar position and note its coordinates, then blow up a small cave complex where they determined the enemy had hidden munitions. That done, we hike back to Camp Blessing.

Weeks later, out on another operation, I discover that the Marines can't always count on air support. As we ground-pound up and down the steep Afghan hills on Operation *Pil* ("elephant" in the Afghan language Dari), the air above us is empty. Now, machine gun rounds zip over my head, splintering tree branches and pinging boulders at the patrol base, coming within inches of people in our group. Lieutenant Kinser directs the Marines to return fire at a ridge above us where he detected muzzle flashes. The grunts squeeze off bursts from M240G light machine guns, M16s, and M249s. The ambush quiets. We maintain our covered position, waiting for air to arrive.

Later that night some members of our attached scout sniper team reflect on the firefight. "No air on station. Safe for them to pop up and hit us," team leader Sergeant Keith Eggers surmises.

No one understands why aircraft haven't been sent to hit the ridge from where we were ambushed; nothing shows up for hours, long after the shooters have fled. We later learn that Rashman had immediately requested support, but an inbound C-130 with landing gear problems shut down the field at Bagram Air Base, grounding the A-10s.

Rashman is on the mission with us this time, and he seems always to be working his radios. Since the battalion has only two forward air controllers to support operations spread across hundreds of square miles, Rashman is called upon to clear air on targets he often not only can't see, but isn't even near—at all hours of the day and night. But he says that the chance to fight alongside infantry is why he chose to temporarily leave his career flying helicopters. "Ask any [Marine] aviator who has done a tour as a forward air controller what their favorite billet has been, and they'll tell you the FAC tour," he maintains.

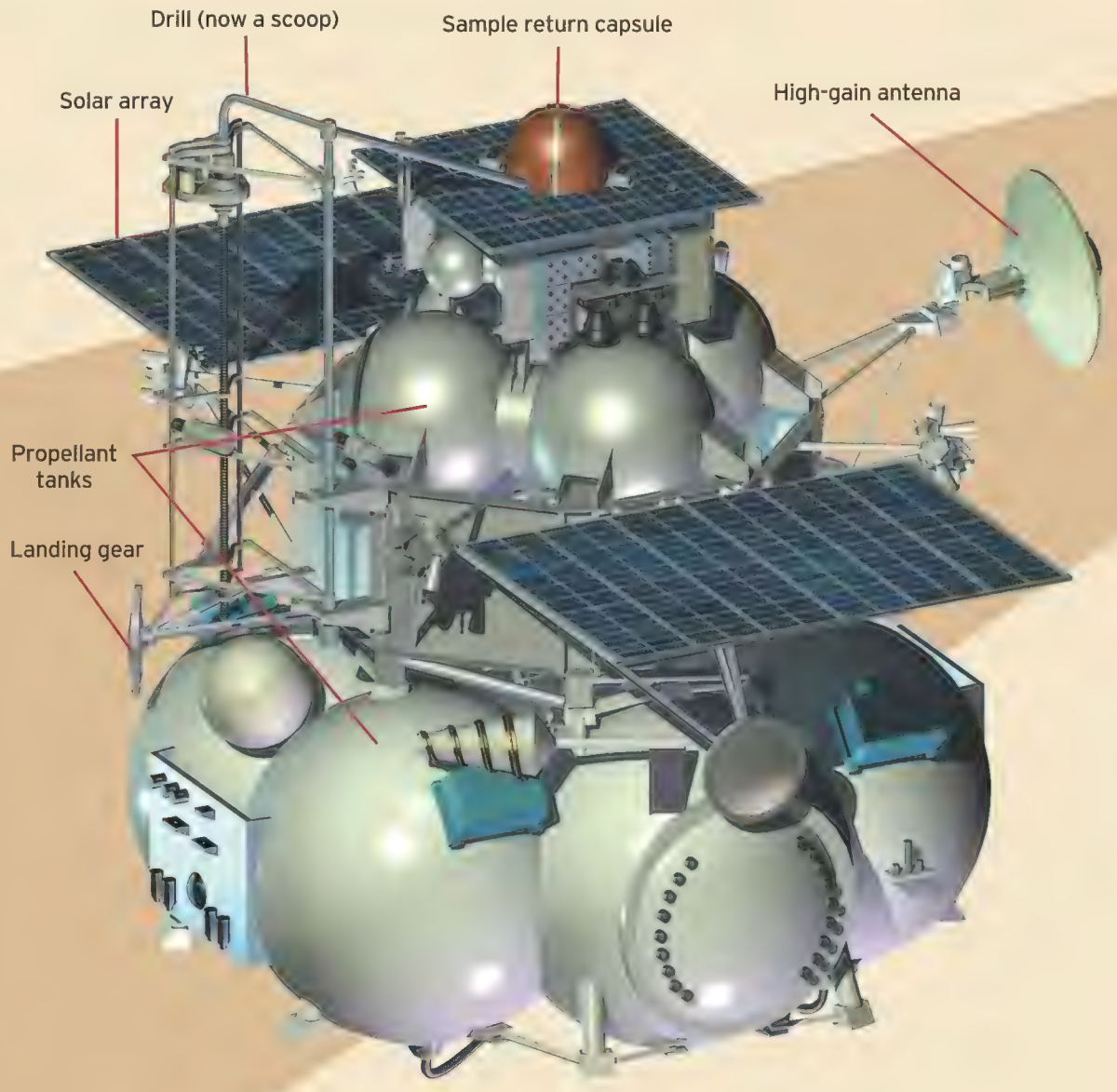
In 2003, Marines got their first glimpse of a system that can receive images from aircraft, including unmanned aerial vehicles, and relay instructions using the system's radio link. Designed originally for the Air Force and called Rover (for Remote Optical Video Enhanced Receiver), the system enables ground forces to see what pilots see through their targeting pods. Now real-time imagery can be fed across the battlefield to commanders, pilots, air controllers, and ground troops. That ability is considered vital when attacking fleeting targets or supporting friendly troops on the move across long distances. Future wars, like current ones, will no doubt require that kind of attack and that kind of support.

A C-130 on the way to Bagram Air Base skims the mountains in Afghanistan (below, left). The ancient battleground awaits Marines now training at Yuma.

TECH SGT CECILIO M RICARDO JR/DOD

MISSION POSSIBLE

A NEW PROBE TO A MARTIAN MOON MAY WIN BACK RESPECT FOR RUSSIA'S UNMANNED SPACE PROGRAM. BY ANATOLY ZAK



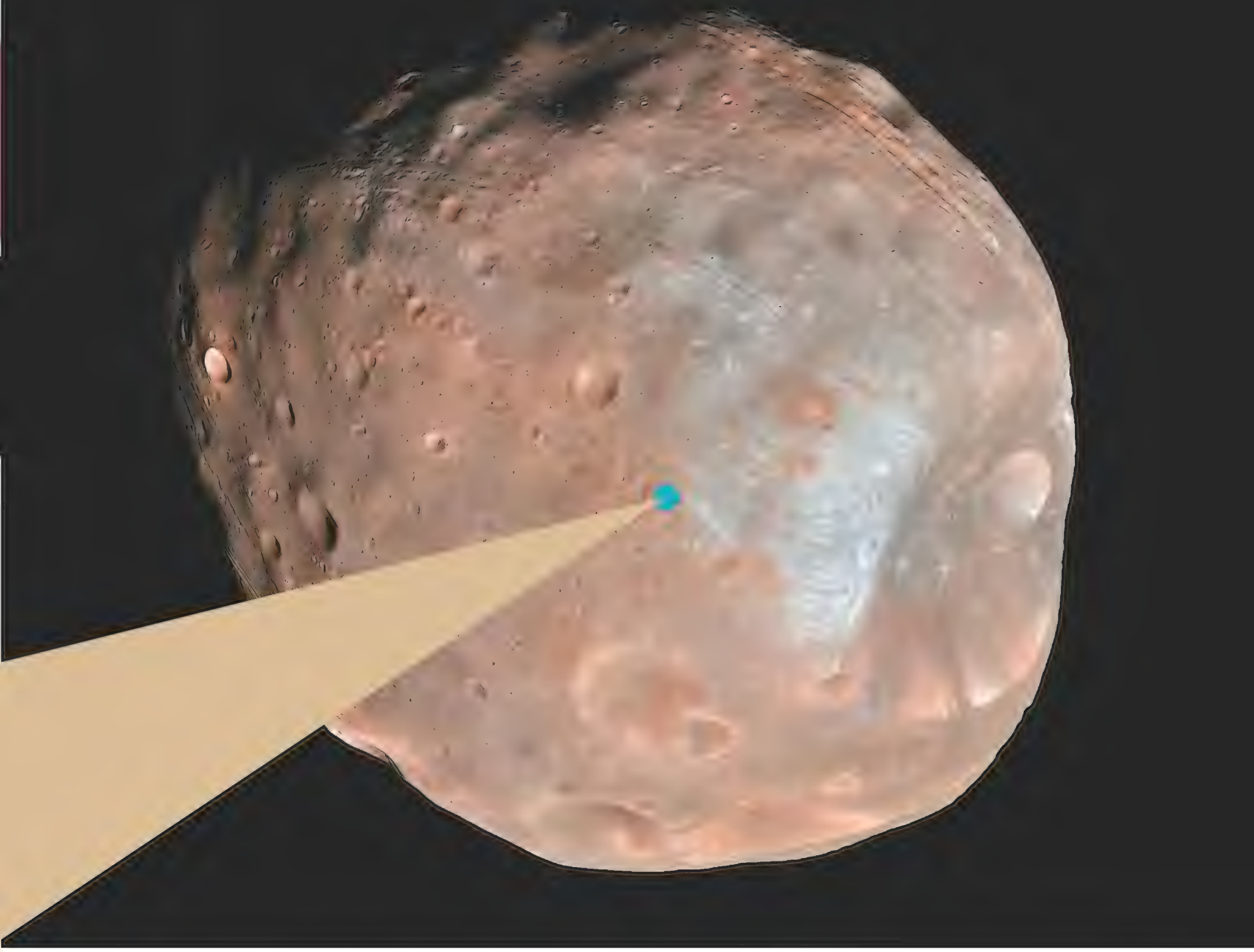
CNES

IMAGINE A WORLD-CLASS ATHLETE who hasn't practiced for several years, but suddenly gets a chance to compete at the Olympics. Or an opera singer walking on stage at La Scala without a rehearsal. These would be good metaphors for Russia's Phobos-Grunt mission. ("Grunt," pronounced "groont," is Russian for "soil.") Planned for launch in October 2009, the probe may become the first to land on Phobos, the larger of Mars' two moons, and the first to bring a sample of its soil back to Earth, so scientists can try to determine whether Phobos was once an asteroid. And it will mark the revival of Russian planetary science after two decades of decline.

Even during the years of the space race with the United States, when Soviet space budgets were hefty, the nation's Mars ambitions frequently met with failure. Of the 20 Soviet or Russian missions aimed at the Red Planet, not one fully succeeded. Other countries have had their troubles too. Five of NASA's 19 Mars missions have failed. Japan's only attempt, launched in 1998, failed to achieve orbital insertion. In 2003, the European Space Agency's sole effort has imaged the planet from orbit, but the lander vanished in the Martian atmosphere.

In late 1996, Russia made its last attempt to leave Earth orbit: Mars-96, a complex mission consisting of an orbiter, two landers, and two surface penetrators. Unlike the Soviet Union, which always launched planetary exploration spacecraft in pairs, Russia could afford only a single spacecraft. With funding always in doubt, many of the project's participants worked for months without pay. Mars-96 finally reached the launch pad at the Baikonur Cosmodrome in Kazakhstan.

On November 16, 1996, Vasili Moroz, a leading scientist at the Russian Space Research Institute, or IKI, the Russian equivalent of NASA's Jet Propulsion Laboratory, watched the launch from mission control near Moscow. The blastoff of the Proton rocket seemed flawless. A mission commentator gave optimistic reports on the various stages of the climb to orbit. "As we learned later,"



Russian scientists have recently improved their probe (opposite) by replacing the drill shown with a scoop device to collect soil in the weak gravity of Phobos, the larger of Mars' two moons.

said Moroz, who died in June 2004, "the commentator was reading a previously prepared list of the orbital insertion sequence rather than reacting to real events. We thought everything was fine, and even had a little drink to celebrate.... Of course we shouldn't have done that." Shortly thereafter, Moroz dropped by a ballistics calculations room where an operator reported that a propulsion system failure had left the craft in a doomed orbit around Earth. It soon plunged into the atmosphere over the Pacific Ocean.

"The loss of Mars-96 was extremely difficult to survive," says Vechaslav Linkin, another IKI veteran. "Imagine: busy, busy work and then suddenly it is all over. We started losing employees. Some found work abroad. I lost several very talented guys, the developers of the software for the Mars rover."

But in the new millennium, fortunes started to change. Skyrocketing oil prices boosted Russia's energy-focused economy. Eventually, money trickled down to the space institute. By 2007 its budget was fully funded, and the loss of talent was stanched. "We now get many young specialists," says Lev Zelenyi, who has led IKI since 2002. "With the brain drain of the 1990s, we kind of lost a middle generation who could now transfer their experience to young specialists. It is almost like during the war. We have a kind of generation gap."

With the worst behind them, Russian scientists young and old are poised to study Mars and Phobos in a single mission. Unlike sister moon Deimos, Phobos, named for the Greek god of fear, the mythical son of Ares (whom the Romans called Mars), circles the Red Planet in a relatively low orbit, and is therefore the easier of the two moons to access.

"It is not the most interesting asteroid in the solar system," says Francis Rocard, manager of solar system programs at Centre National d'Etudes Spatiales, France's space agency. CNES has supplied a gas analysis package to study the molecular composition of Phobos' soil. "But we will have access to it, and we will probably confirm that it is effectively a captured asteroid." Rocard hopes the probe will find Martian material on Phobos; if so, it would have got there the way some of it reached Earth: by ejection of Martian materials during impacts of asteroids or big meteorites.

The spacecraft, which is being assembled near Moscow at

NASA/JPL/UNIVERSITY OF ARIZONA

DMITRY AZAROV/KOMMERSANT (2)

Bulging propellant tanks define the Fregat upper stage rocket (left) that will power Phobos-Grunt on its 10-month trip to Mars. In March 2007, Russian President Vladimir Putin (looking down) visited NPO Lavochkin near Moscow, where the spacecraft is being built.

NPO Lavochkin, successor to the Soviet Lavochkin Design Bureau, should reach Mars in late July or early August 2010. It will orbit the planet for almost nine months before landing on Phobos. There it will be subjected to power and communications blackouts, when Mars and Phobos block the sun and Earth.

"Phobos ends up in the shadow of Mars," explains Aleksandr Zakharov, deputy director of IKI. "In the worst situations, this shadow lasts for almost an hour out of an eight-hour orbit."

Immediately after the touchdown, Phobos-Grunt will load a soil sample into a return rocket. In case of a breakdown of communications with mission control, it can enter an emergency mode to collect samples and still send them home in the return rocket. Normal collection could last from two days to a week.

"There are a number of complications in taking that soil," Zakharov says. "We are working in near-weightlessness, and to test this on Earth is practically impossible. Therefore, we go into all kinds of tricks."

Scientists hope that Phobos-Grunt will beam to Earth a panoramic view of Phobos' surface to help scientists select targets. For collection, engineers had hoped to use a variation of a drill the Soviet Luna probes employed to return samples of Earth's moon in the 1970s. But in the low gravity on Phobos, which has an average diameter of less than 14 miles, the spacecraft will weigh less than a pound. The action of a drill might overturn the lander, depending on how hard a surface it encounters. So IKI developed a small robotic arm to scoop spots around the craft.

"Obviously, [the scoop] loses the ability to drill deep into the surface, as Luna did," Zakharov says. "However—and I was personally involved in the analysis of it—the drills by Luna to the depths of more than one meter showed that there is not much difference in the chemical composition of the soil with increased depth. Therefore, it seems [drilling] is not really necessary."

The scoop can penetrate about an inch below the surface. "What's really critical here is to take rocks," says Zakharov. "Because the surface regolith was reprocessed many times, it is very possible it reflects the history of something other than Phobos itself."

The robotic arm can collect rocks up to about half an inch in diameter. It ends in a pipe-shaped tool that splits to form a claw. This encloses a piston that will push the soil sample into an artillery-shell-shaped container. A light-sensitive photo-diode in the claw will help scientists confirm that the device did scoop material. They hope also to see images of trenches the claw leaves on the surface. The manipulator should perform 15 to 20 scoops yielding a total of three to five and a half ounces of soil.

"Nobody knows what Phobos' soil is going to be like," Zakharov says. "It might be perfect beach sand. But we hope—and something is whispering to us—that it will be a combination of sandy soil and small rocks." IKI scientists studied images from the NEAR probe, which NASA landed on the asteroid 433 Eros in 2001, and concluded that the soil on Phobos may be similar. The team also created a model of Phobos' soil, based on samples of Earth's moon, and found that it likely sticks together well

IKI SPACE REASEARCH INSTITUTE

enough to stay inside the claw during the transfer to the return container. "We hope that in the lack of gravity, this sticking effect will be even stronger," says Zakharov.

The return rocket will sit atop the spacecraft, and will need to rise at 22 mph to escape Phobos' gravity. To protect experiments remaining on the lander, springs will vault the rocket to a safe height, at which its engines will fire and begin maneuvers for the eventual trip to Earth.

The lander's experiments will continue in-situ on Phobos' surface for a year. To conserve power, mission control will turn these on and off in a precise sequence. The robotic arm will place more samples in a chamber that will heat it and analyze its spectrum. This analysis might determine the presence of easily vaporized substances, such as water.

In addition to its promised scientific harvest, Phobos-Grunt is rejuvenating old alliances between Russian scientists and their colleagues abroad. Such cooperation reached its finest hour in 1984, when the Soviet Union launched the Vega 1 and 2 probes to Venus. By releasing balloons into that planet's atmosphere and a flyby of Halley's Comet, Vega returned volumes of scientific data, forging worldwide scientific cooperation. The spacecraft carried science payloads produced in more than half a dozen countries, and the comet approach included a flotilla of probes from Japan and Europe.

"After this mission," Linkin remembers, "there was an impression that we can achieve so much through cooperation."

Unfortunately, the success was followed by one failed and one only marginally successful mission to Phobos, plus the fiasco of Mars-96, which deprived scientists around the world of data and research, and eroded their decade-long trust of the Russians. "There was an emotional aftermath from the Mars-96 failure," Linkin says. "Everything always fails on your side," his foreign colleagues complained to him.

But these scientists are connecting again. In December 2005, the French and the Russians started discussing cooperation on Phobos-Grunt. Before long, French instruments were on board.

Then, in 2006, the Russians announced that the Chinese would add a 243-pound spacecraft, Yinghuo-1, to Phobos-Grunt to study Mars' atmosphere. This maxed out the capabilities of the planned Soyuz rocket and required a switch to a more powerful and expensive Zenit booster.

Others are piggybacking too. Perhaps the most unusual passenger on Phobos-Grunt comes from the U.S.-based Planetary Society. Its Living Interplanetary Flight Experiment, or LIFE, will send 10 types of microorganisms and a natural soil colony of microbes on the three-year round trip. "This would be the first time live organisms take an interplanetary flight"—on a controlled experiment, at least—says Louis Friedman, the society's executive director. The results may fuel the debate about whether meteorite-riding organisms can spread life throughout the solar system.

Some fear that the eight-ton Phobos-Grunt—expected to carry up to 20 experiments—has ballooned into a Noah's Ark of science. Friedman advises having a little patience with the Russians' approach. "We might find it strange," he says, "but their philosophy is, if the new task is not affecting the main goal of the mission, it can be added. They take all these changes much more easily than we do. In the '80s they were planning to drop balloons in the atmosphere of Venus. Then they decided to take the same spacecraft to Halley's Comet almost at the last minute, and they did it successfully."

Others are less certain. "The Phobos-Grunt mission is very ambitious," says CNES's Rocard, "and I think the Russians are not very confident in their own technology. They are not sure they could actually bring back the samples. That is why they want some scientific return by remote-sensing Mars, or in-situ experiments on Phobos." He speculates that a hidden rationale for Phobos-Grunt's broad nature is winning support within the Russian scientific establishment. "This is an internal problem in Russia. If they make too narrow a selection [of experiments], there will always be scientists who are not happy. They would keep criticizing the mission. My feeling is 20 instruments are too much. In the U.S. they put six instruments [on a typical planetary probe]."

A major milestone comes at the beginning of next year, when IKI is scheduled to deliver the science instruments for installation on the spacecraft.

"We have a good chance that Phobos-Grunt will fly," says Zelenyi of the 2009 launch date. He adds that Phobos-Grunt could still go to Mars with its full payload in 2011. That year, the planet's orbit won't synch with Earth's the way it will in 2009, so the mission would require the more powerful Zenit. "It would not be a tragedy," he says.

Successful or not, Phobos-Grunt will pave the way for a caravan of Russian probes to Mars and other planets, Russian space officials insist. But a success would boost the nation's planetary science program and its standing in the world. Russian scientists know that very well. They took this gamble before.

CNES

The Russian Space Research Institute, or IKI (opposite), in Moscow, is the equivalent of NASA's Jet Propulsion Lab, providing mission control for Russia's deep-space probes. At an IKI exhibition last year, a full-scale mockup of Phobos-Grunt generated buzz. Will it usher in a new golden age of Russian planetary science?

S.S. 550 A.]

ILLUSTRATIONS TO ACCOMPANY

NOTES ON THE INTERPRETATION OF AEROPLANE PHOTOGRAPHS.

Series A.

PLATE 2.

RAM ILLUSTRATING THE RECONSTRUCTION, FROM THEIR OWS. OF FIVE CIRCULAR OBJECTS SEEN VERTICALLY I ABOVE.

1. as they would appear without shadows.

Shell hole · Mound · Haystack · A.A. gun emplacement with concrete centre for gun · Bushy tree

2. as they appear on a photograph

3. as viewed from the ground.

without shadows.

b.

shadows.

b.

covered, and possibly occupied

C · Elbow rest · Dugout Entrances. · A · Ladder to catch loose Earth. · Fire step · B · Floor of trench. · D

PRINTED BY No 6 ADVANCED SECTION A.P.M.S.

The book that robbed the enemy of his secrets. Top page: The upper photo shows two roughly parallel trench lines, running diagonally – top line, Germans; bottom, British. Lower photo: Trenches surrounded by bomb craters. Second page: A key to shapes shows a circle can be a haystack or a gun emplacement.

PORTRAIT *of* THE ENEMY

PHOTOGRAPHS TAKEN FROM THE WORLD'S FIRST WARPLANES CHANGED THE COURSE OF BATTLE. *by Robin White*

THE PADDED ENVELOPE arrived on my doorstep with an ominous thump. The return address, Knox Burger Literary Agency, confirmed my apprehensions: It was the manuscript I'd mailed to my irascible literary agent only a week before. Apparently, he hadn't liked it.

Knox Burger had learned his trade during the Second World War, writing from Tinian in the Mariana Islands for *Yank* magazine. He flew on the B-29 raid that burned the heart of Tokyo to ash. He was one of the first journalists to walk that city's streets after the war, and sent back a haunting interview with a Japanese fireman who'd tried to put out a firestorm with a bucket.

Knox was and remains almost impossible to please. Even worse, he's usually right. So I wasn't eager to tear open that package and see what he'd done to my manuscript.

But I was wrong. Inside I found a large book of photographic plates: *Notes on the Interpretation of Aeroplane Photographs*, bound in heavy cardboard, peeling tape, and twine. It looked, even smelled, old. And in Knox's spare, demanding style, a note: "I found this in my father's things. Make sure it finds its way into the right hands."

I'd researched modern intelligence gathering for a book about submarines, *Hostile Waters*, that I'd co-authored. But "aeroplane?" How old was this book? I opened it, taking care with the fragile binding. A handwritten label said the book had been issued in 1918 to Knox's father, Captain Carl Burger of the 344th Infantry, United States Army.

I've seen stills taken from the Predator, a General Atomics unmanned aerial vehicle that flies reconnaissance missions over Iraq; the old plates in Captain Burger's book were far sharper. Taken during the Great War, the photographs were astonishingly clear and detailed, showing shell-pocked moonscapes around the Somme River in France, trenches, and the tracks left by soldiers rushing to battle, as well as a chaos of trails made by men fleeing for their lives. In one, I could even make out a biplane rising up from an enemy aerodrome.

The accompanying text began: "In the British Army, the whole trench system of the enemy is photographed from a standard height of 6,600 feet at least once every ten days."

Could "whole trench system" mean the entire Western Front, from the North Sea all the way to the Swiss border and beyond? That was 500 miles—a lot of flying, a lot of photographs.

The military's view on aviation had clearly undergone a major shift. Only a few years before *Notes* was issued, General Ferdinand Foch of France had said, "Flying is merely a sport and from the military point of view has no value whatsoever." When Austrian Archduke Franz Ferdinand's 1914 assas-

A ragtag fleet of Royal Flying Corps observation craft. British airplanes spotted Germans marching south from Belgium, information that bought time to muster a defense.

NASM 2A45642~A

OPPOSITE: PHOTOGRAPH BY ERIC LONG

Three photographs from *Notes*. Above: a base in Belgium hosting numerous airplanes and hangars.

An image of trenches demonstrating how sunlight illuminates their covers, entrances, and bottoms.

In an area between the Ancre and Somme rivers, tracks leading to the frontline in France.

sination in Sarajevo sent the world to war, reconnaissance was conducted by cavalry—that's right, men on horses.

As for aerial reconnaissance, early observers went aloft over France in tethered balloons armed with nothing more than sketchpads. Now, according to *Notes*, overlapping photographs covering half a continent were routinely shot from more than a mile high, with camera lenses that were good enough to show whether a trench was full of soldiers or mud.

Aerial reconnaissance, like aviation itself, had entered World War I as a primitive art. How had it become a science so quickly? A phrase in *Notes* provided a clue: "The disregard of aerial photographs has cost many avoidable disasters and useless loss of life."

THE GERMANS HAD LAID OUT the conquest of Europe in great detail in the pre-war Schlieffen Plan, a strategy for conquering the continent by way of a lightning thrust through neutral Belgium, the capture of Paris, and, in six weeks, German forces on the English Channel. Like most such plans, it didn't survive contact with the enemy. The quick war of maneuver bogged down to a bloody stalemate. One of the main reasons: aerial reconnaissance.

At the outbreak of fighting, on August 1, 1914, the French could muster 132 military airplanes. The British had 40 able to fly across the Channel. Though the Italians had been the first to use airplanes in war, sending Blériot XIs to Libya in 1911 to bomb, scout, and even photograph Turkish troops during the Italo-Turkish War, they were years from joining the conflict. The Russians planned to adapt Igor Sikorsky's immense, four-engine Ilya Mourometz—a precursor to the modern airliner with a heated, lit cabin and bathroom—as a bomber, but at the start of the war, the Russian air force consisted almost entirely of aircraft imported from France, Britain, and Germany, sources that dried up at the first shot.

All military aircraft of the day served only as observation platforms, meant to augment the reconnaissance work of tethered spotting balloons. None was armed.

The first of the Allied scouts took off on August 19, 1914. They were hampered by typical summer weather: haze, heat, clouds, and thunderstorms. There were no charts, no navigation aids of any kind. The results were predictable. A British pilot left his field in northern France in a Blériot XI and promptly got lost, managing to fly directly over

Brussels without recognizing it. A French pilot in another Blériot came down in a town that was still in Belgian hands and later reported back that "an excellent lunch was provided by the garrison commander."

And the Germans? They had about 200 aircraft, split between the Eastern and Western Fronts, plus a secret weapon: a few aerial cameras with superb Zeiss lenses.

On August 22, the day when British and German soldiers first clashed, 12 British BE 2a biplanes (a 1913 design that, like the Wright *Flyer*, used wing warping to turn) were sent up to locate the enemy. They didn't have to fly very far: an entire German army was marching south from Brussels, split into vast columns like the prongs of a pitchfork. The Germans had thrown the French forces back, and the British had been left alone and exposed.

The British commander, Field Marshal Sir John French, was an old cavalry officer who didn't have much use for airplanes. When one BE 2a pilot reported what he'd seen, French stormed, "How do you expect me to carry out my plans if you bring me all these bloody Germans!"

Later, however, in a post-war memoir he admitted, "This was our first practical experience in the use of aircraft for reconnaissance purposes. The timely warning they gave enabled me to make speedy dispositions to avoid disaster." The information from the aerial scouts allowed the British to maneuver out of the way of the seemingly unstoppable German advance. French saved his army.

A few weeks later, with Germany's noose on Paris tightening and the government evacuating, Corporal Louis Breguet, flying an AG 4 he'd designed himself, discovered a gap in German lines. The French attacked, stopping the invasion just 30 miles from the city. With the war barely begun, aerial reconnaissance had already changed the course of battle.

On the Eastern Front, in the epic Battle of Tannenberg, the Germans paid attention to their scouting pilots; the Russians ignored theirs. The result: Between August 17 and September 2, 1914, an entire Russian army was destroyed, its soldiers killed or captured, its commander dead by his own hand.

As the value of aerial intelligence soared, stopping it became ever more critical. A pilot's life, already endangered by bad weather, unreliable engines, fragile airframes, and anti-aircraft fire, was about to become a lot more dangerous.

ON MONDAY, OCTOBER 5, 1914, a north wind blew across the vineyards near Rheims in northern France. For the soldiers of the German Second and Third Armies huddled in trenches, the cold was proof that the Six-Week War they'd been promised had been ill-named. The men of the nearby French Fifth Army weren't any happier, but at least they could suffer with bottles of the excellent local champagne.

The drone of airplane engines turned thousands of faces up to the sky. A German Aviatik, a two-seat observation craft, was approaching at 3,500 feet to survey French lines. A second aircraft, a French Voisin, was above and behind it.

Lieutenant Fritz von Zangen, the Aviatik's ob-

Two perspectives, oblique (top) and vertical, of an area in northern France. Along with angle, light and shadow add dimension to features of interest, such as the Butte de Warlencourt (circled), an ancient burial mound the Germans held during the war.

server, commanded the recon flight from the front cockpit. He had an artillery map on his lap. His pilot, Sergeant Wilhelm Schlichting, sat huddled behind him. It seems likely that neither one saw the Voisin swooping down into their "six."

The ungainly two-man Voisin resembled a baby stroller with wings. It was returning from a bombing mission when its pilot, Sergeant Joseph Frantz, spotted the Aviatik. He dove on it, overshot, then banked back in.

First the French soldiers, then the Germans climbed out of their trenches to stare up at a most unusual sight: the world's first dogfight.

When the war began, opposing airmen could only shake their fists at each other. They soon armed themselves with pistols, rifles, shotguns, even grappling hooks and hand grenades. But Frantz's front seat observer, Mechanic Corporal Quenault, had something new: a Hotchkiss machine gun, and as the Aviatik grew large in his sights, he fired.

The German pilot tried to dive away but Frantz stayed with him. The French soldiers on the ground cheered. Then the balky Hotchkiss jammed. The two airplanes were just 600 feet above the ground. The frustrated French gunner pulled out a rifle, aimed, and fired. The bullet struck Sergeant Schlichting. The Aviatik flipped and crashed in a ruin of timbers and canvas.

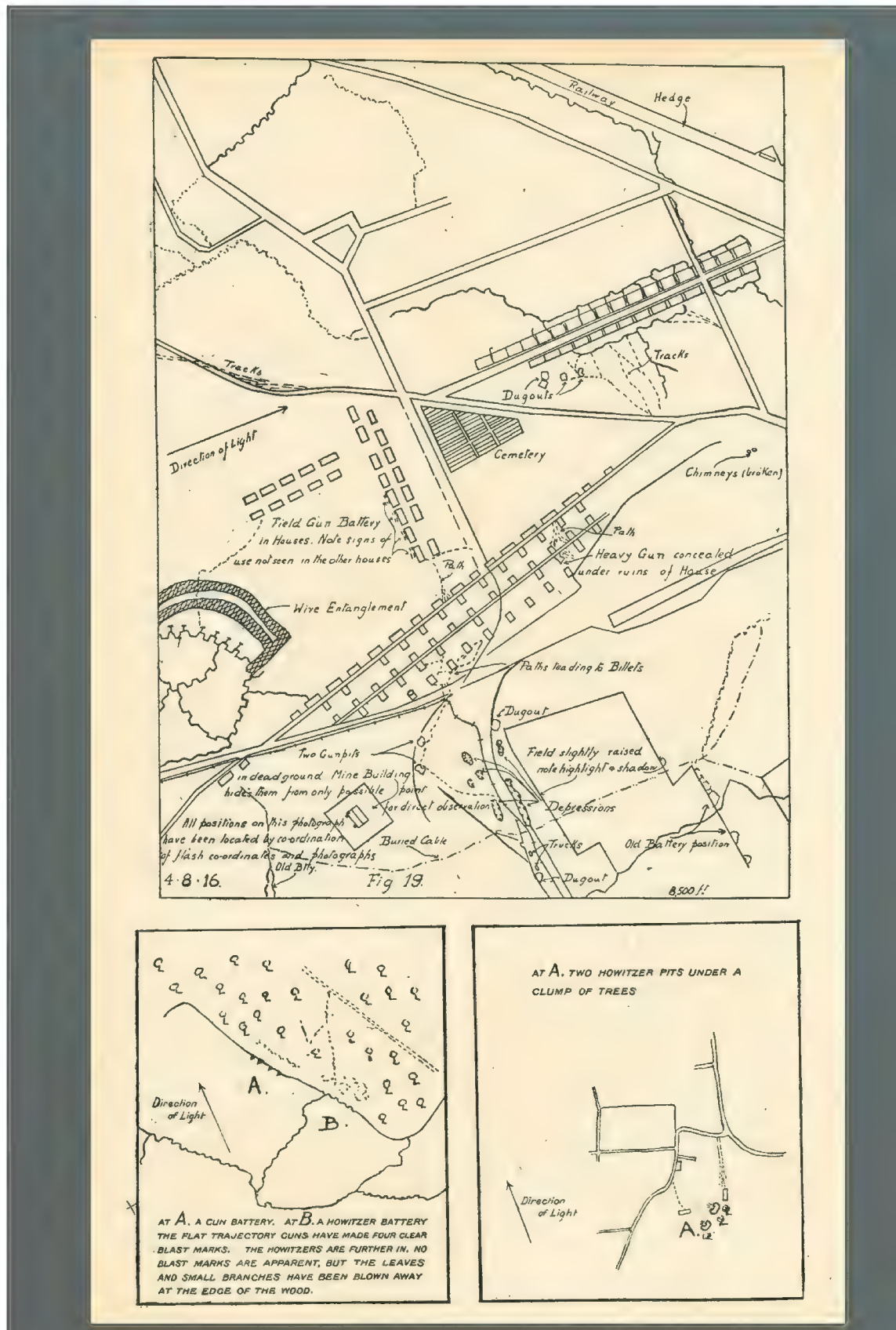
A new chapter in warfare had begun. For pilots in fast, single-seat Fokkers armed with fixed guns, fragile kites with sputtering motors were meat on the table. The vulnerable reconnaissance airplane had to adapt or die. A Farman F.20 of 1914 cruised at 68 mph and could climb, on a good day, to about 8,000 feet; by 1918, the Italian Ansaldo SVA 5 reconnaissance airplane could climb to 20,000 feet and outrun the swiftest single-seat fighters. It was the SR-71 Blackbird of its day.

Cameras improved as well. The long lens of the British Type L enabled an observer to fly higher, out of the reach of "Archie" (anti-aircraft fire). Still, it was one thing to take a good aerial photograph and survive to bring it home, and quite another to train someone who had never seen the world from the air to make sense of it.

A photograph is a near-exact projection of the terrain upon a two-dimensional plane, and in the words of *Notes*, people without "air-sense" literally could not tell a haystack from a hole in the ground. France led the pack in photographic analysis. Capitaine Jean de Bissy published his *Note Concernant l'Interpretation Methodique de Photographies Aeriennes* a year before the war commenced. De Bissy's pamphlet became the model for all subsequent aerial photographic training. It morphed into a number of longer, more detailed publications that, unlike the high-quality camera lenses they hoarded, the French willingly shared with their British allies.

Lieutenant J.T.C. Moore-Brabazon, who in 1909 had won London's *Daily Mail* prize for the first all-British flight of a circular mile, tried to get someone interested in the French manual. He had a hard time. The new technology seemed rude. "The Army took the greatest exception to an enemy who indulged in dirty tricks," he wrote in his 1956 memoir, *The Brabazon Story*. "Aerial photography

Every photograph in *Notes* is accompanied by a schematic drawing with annotations showing features of interest. In the pairing below, the large photograph, taken in France, shows billets, dugouts, and guns hidden among the houses. In the



NASM 9A00225~A

smaller photographs, interpreters found subtle signs in the woods suggesting the presence of howitzers. Right: one of the earliest examples of air-to-air photography, showing a Nieuport XI fighter over the French countryside.

invaded a privacy that had always been accorded an enemy."

The war quickly rendered peacetime courtesies obsolete, and the British army published *Notes on the Interpretation of Aeroplane Photographs*, the English version of the original French book, in November 1916. When America entered the war the next year, Major James Barnes and First Lieutenant Edward Steichen—the former an explorer, the latter the most famous photographer of his time—surveyed French and British material on aerial photography. Together, they produced the copy of *Notes* issued to my literary agent's father back in 1918.

So just how much do the plates in *Notes* reveal to an infantry intelligence officer like Captain Burger back in 1918? Quite a bit.

Where was the enemy? Take a look at how markings left by recently buried communications cables point, unerringly, to what we today might call a "command and control node." What were the enemy's strengths? Look how much information the analyst squeezed from one plate: billets for troops, hidden heavy guns, batteries of howitzers, even trucks on the road. What is the enemy up to? We see "No-Man's Land" being prepared for an all-out attack: new "saps" (exploratory trenches) snaking out from German-held territory to foot trails left by daring British patrols.

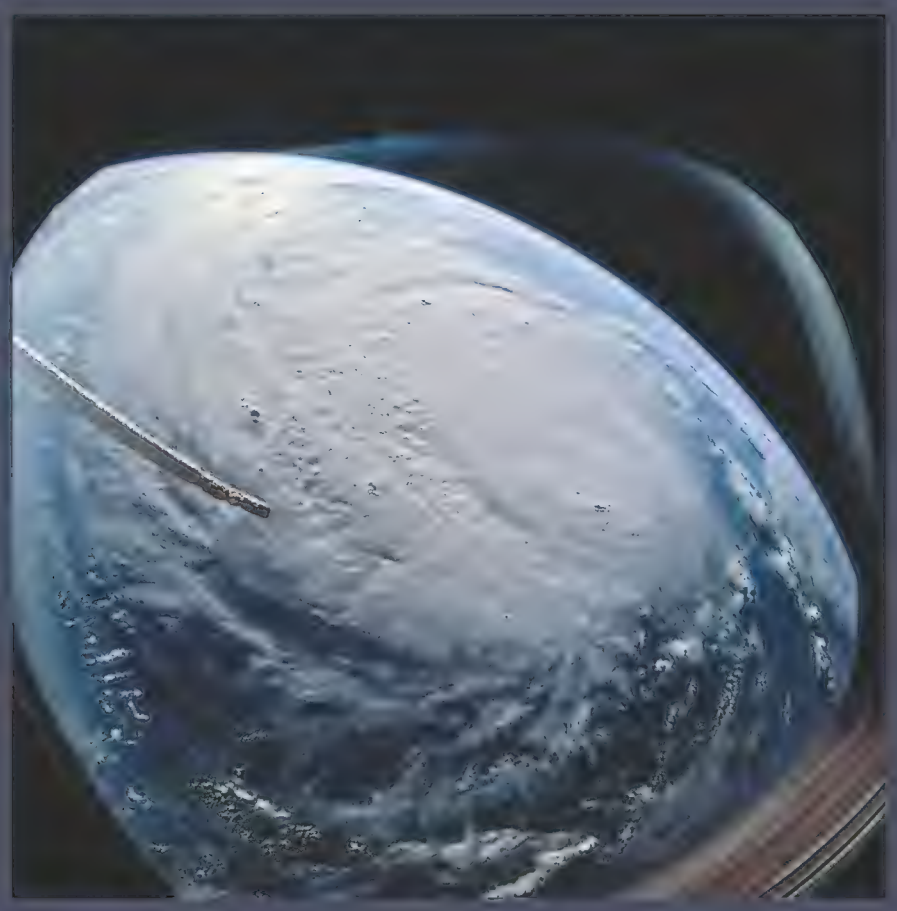
The publication of *Notes* marked the end of aviation and aerial photography as primitive arts, and their birth as sciences.

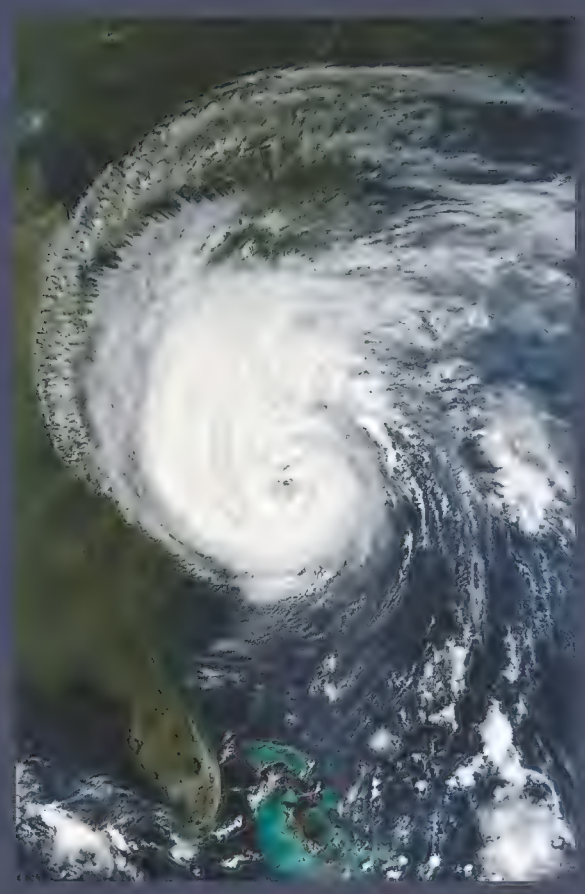
Not that art and inspiration were completely banished. In a postwar memoir, *Notes* co-author James Barnes writes: "Interpreting aerial photographs demands a peculiar mind—the type that enjoys chess problems or crossword puzzles. To the uninitiated, a photograph of a line of trenches and myriad shell holes means very little. But to a puzzle solver, they tell a story. Often his imagination is set on fire by some puzzling little thing, the reason for which he cannot quite discover. Like a game of poker with aces up the sleeve, the battle between the camera and camouflage is on. And then, all at once, he has it!"

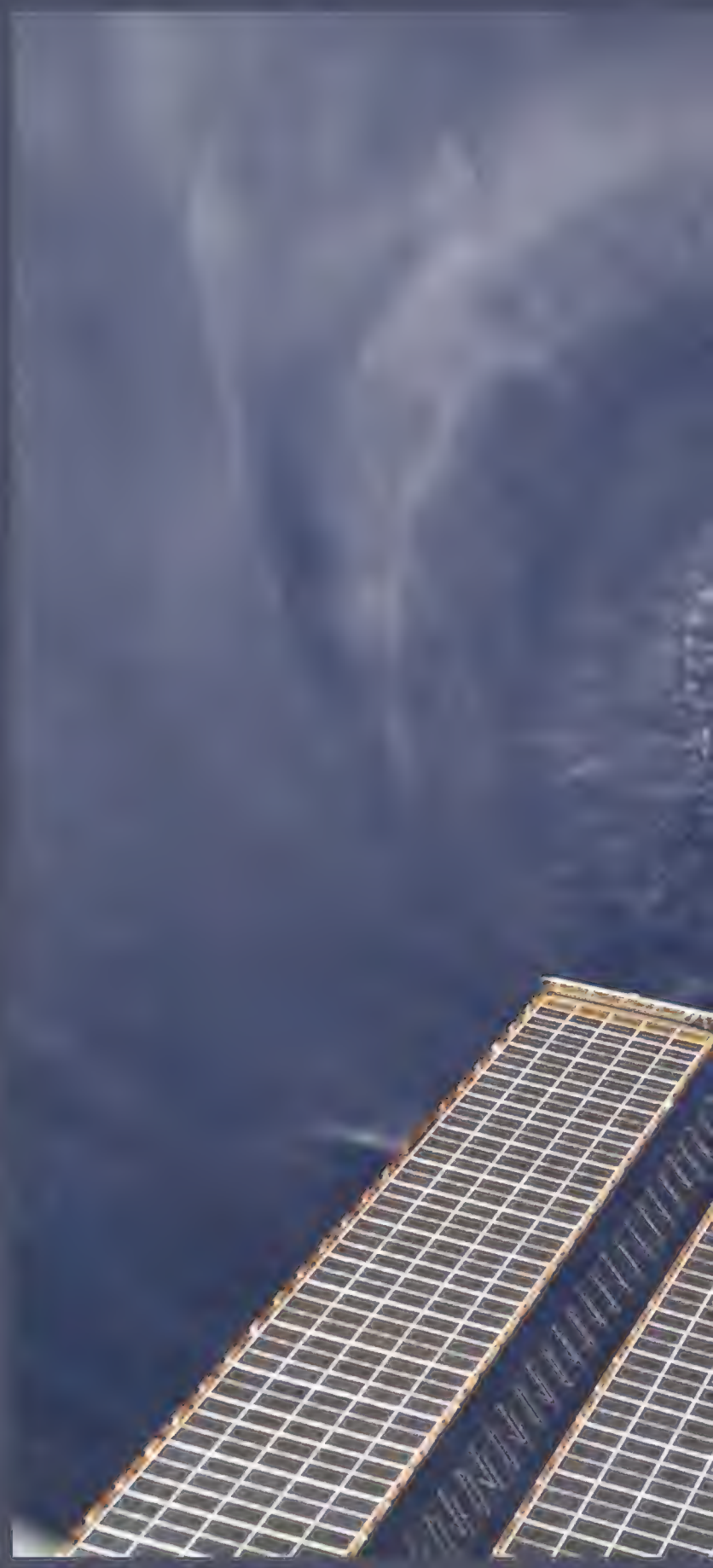
Today, the puzzle solvers can be found at places like the National Reconnaissance Office in Chantilly, Virginia, working to decipher images returned by U.S. reconnaissance satellites that continuously orbit over the world's trouble spots. Despite the many advances in technology, these analysts know exactly what Barnes was talking about 90 years ago: the thrill of having your imagination set on fire by some puzzling little thing, and then, all at once, you've got it. The enemy is revealed.

Sightings

PICTURES WORTH A SECOND LOOK

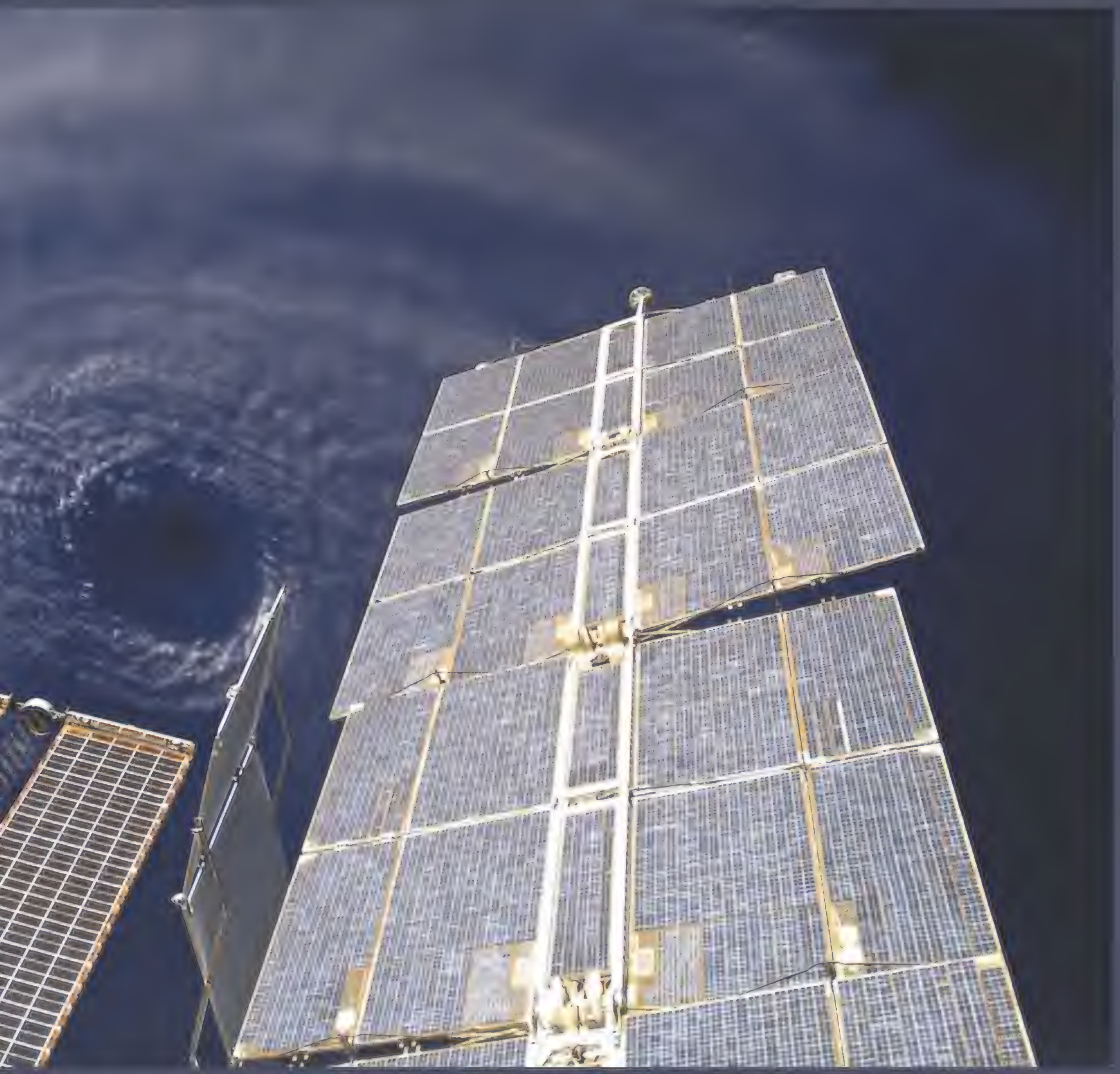






KEEPING AN EYE ON HURRICANES from orbit began in September 1961, when NASA's Tiros III satellite returned an image of Hurricane Esther. Since then, dozens of satellites and astronauts have gazed down on the megastorms.

Hurricane Marilyn (top, left) smothered the Caribbean Sea on September 17, 1995. The crew of the space shuttle *Endeavour* captured the storm through a fisheye lens that exaggerates the curvature of Earth. The shuttle's robot arm appears in the left part of the frame. From a front-row seat on the end of that arm, mission specialist Michael Gernhardt watched the storm. "For a moment I was overcome with a great sense of the contrast of the technology that put me there against the raw force and beauty of nature," he says. A category 3, Marilyn was the 13th named storm of an unusually busy season, and followed close on the heels of Hurricane Luis, which the same shuttle crew, mission STS-69, observed earlier in their 11-day



flight. Marilyn claimed 13 lives and caused $1.5 billion in damage, mostly in the U.S. Virgin Islands.

The eye of Hurricane Ivan (above) stared up at the solar panels of the International Space Station on September 11, 2004, where astronaut Mike Fincke shot the storm as it churned through the Caribbean. Scientists at NASA's Stennis Space Center in Mississippi calculated that the wave height in Ivan's eyewall exceeded 130 feet. Packing winds of 160 mph, Ivan was a solid category 5 and the sixth most powerful hurricane ever recorded at the time (now 10th). It claimed 92 lives and left $16 billion in property loss across several Caribbean islands, the United States, and Venezuela.

Hurricane Isabel, imaged by NASA's Terra satellite (opposite, bottom), bore down on the North Carolina coast on September 18, 2003. The deadliest and costliest storm of that season, Isabel left six million people without power, caused $3.6 billion in damage, and claimed 16 lives.

Hard Hat Zone

UNTIL THE LATE 1940s, fighter pilots had little more than cloth or leather helmets and goggles to protect their heads from oil spray or bumps in the cockpit. With the arrival of high-performance jet aircraft and ejection seats, the U.S. military began to take head protection seriously. The result: a "hard hat" for flight crews—the H-1 helmet for the Navy and P-1 for the Army Air Forces (forerunner of the Air Force)—that became standard-issue gear in 1947.

"Take a fighter helmet from the early 1950s and one from a contractor's lot now, and they make them not as cheaply but largely the same," says Harry Hurt, who runs the non-profit Head Protection Research Laboratory in Paramount, California. While today's helmets have the same basic structure—a hard outer shell mated to a soft impact-absorbing liner—as those designed six decades ago, their shapes, colors, materials, and capabilities have changed significantly.

For example, Boeing has developed a helmet-mounted system to assist fighter pilots in navigation and help them aim and fire weapons at targets. In an oval area on the right inner side of a pilot's visor, the system displays such information as the location of other aircraft in the formation, status of the pilot's weapons, and time, range, and direction to the target—reducing the time he would need to look at the instrument panel. A combined 2,500 of the helmets are flown in today's F-15, F-16 and F/A-18 fleet and another 2,500 are on order, including some for weapons operators in the back seats in the F/A-18F Super Hornet.

Fighter pilots today need look no farther than their visors for key flight data.

Boeing took the Air Force HGU-55 and Navy HGU-68 carbon fiber helmet shells made by Gentex Corporation of Simpson, Pennsylvania, and modified them to keep the visor system level with the pilot's eyes. Boeing then enhanced the helmet liner with an energy-absorbent filler from Oregon Aero made of Confor, a version of the spongy urethane foam used for astronaut couches in the Apollo capsules. For a custom fit, military personnel can trim the filler until the helmet hugs the face to within the thickness of a sheet of paper. "When you put the visor down, you have to do a little trimming depending on the shape of the pilot's cheeks or nose," says Phil King, Boeing's helmet systems program manager. "Before, if the helmet shifted a bit, it wasn't a big deal." But the system is sensitive to even tiny variations from a position parallel to the eyes, so a snug fit is crucial. Each helmet costs about $175,000.

In January, Gentex won a $95 million contract to make up to 24,000 copies of a Modular Aircrew Common Helmet to replace the 27 varieties now worn by U.S. military pilots. The new helmets would cut the military's parts inventory and standardize attachments for life support systems. Only the outer shell would vary with different airplanes or helicopters.

Early fighter helmets, like this 1950s-era Navy APH-5, were rugged but dumb.

ROGER A. MOLA

LEFT: COURTESY GENTEX CORPORATION; ABOVE: COURTESY AIR POWER AUSTRALIA

Live your life, Love your bath tub.

As featured in AARP Magazine

Put the smile back into bathing with a Premier Walk-In Tub.

If you struggle taking your bath, talk to us at Premier about our extensive range of walk-in tubs.

- Enjoy a relaxing bath again, without the fear of slipping or falling.
- The walk-in door feature allows easy access and exiting at all times when taking a bath.
- Hydrotherapy jets option to soothe aches and pains.

-Ed McMahon

CALL NOW
TOLL FREE
1-800-578-2899
SOURCE CODE 101088

Please send me a FREE Premier brochure today!

Premier™ Care in Bathing

Name

Telephone

Address

City

State

Zip

Send to: Premier Bathrooms Inc, 2330 South Nova Rd
South Daytona, Florida 32119

CODE 101088

Magic in the Mojave

Spacecraft designer Burt Rutan takes us a little closer to the future.

MOJAVE AEROSPACE VENTURES LLC/SCALED COMPOSITES

On August 7, 2003, *SpaceShipOne* made its third test flight. After being released by its mothership, *White Knight*, *SpaceShipOne* glided past the Tehachapi Mountains in southern California and landed safely 19 minutes after separation.

SpaceShipOne: An Illustrated History

by Dan Linehan. Zenith Press, 2008. 160 pp., $34.95.

THOSE OF US WHO GREW UP during the space race were promised an amazing future. When the 21st century finally arrived, I forgave those who'd suggested that I might date Barbarella or meet Mr. Spock, but how could they have been so terribly wrong about the flying cars? But then, in April 2003, aircraft genius Burt Rutan gave us *SpaceShipOne*, the world's first privately owned spaceship and winner of the $10 million Ansari X Prize. In *SpaceShipOne: An Illustrated History*, author Dan Linehan gives a thorough behind-the-scenes account of how the future suddenly became cool again. Packed with more than 230 photographs and detailed drawings, *SpaceShipOne* is a visual feast that puts the reader inside the hangar as well as the cockpit. Don't think of this as a coffee table book, however. Linehan has done his research. Through interviews, transcripts, and flight logs, he tells the story of the history-making effort while revealing many details: Such enormous wings were needed to help ferry *SpaceShipOne* aloft that it actually took the carrier airplane, *White Knight*, longer to touch down than it took *SpaceShipOne* to go into space and land. Interviews with the people who worked on the project are as fascinating as the spaceship itself, and through their stories I found myself believing that the future is finally here.

BOB CRADDOCK, A SMITHSONIAN INSTITUTION GEOLOGIST, HAS BEEN A VISITING FACULTY MEMBER AT THE UNIVERSITE PARIS-SUD AND THE UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO, WHERE HE HAS LECTURED ON SPACE AND PLANETARY SCIENCE.

FREE Hearing Aid Catalog

Shop by mail and Save 80%

- Products praised by *The Wall Street Journal*
- 100% Risk-FREE offer
- 45-day home trial
- Arrives ready to use
- Compare to hearing aids costing $1,000 or more

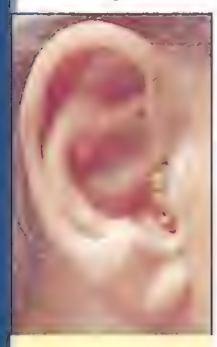
Our Customers Say it Best!

Customer comments on file – printed with their permission. Of course, individual results may vary.

"Price is right! Works better than aids I bought locally."
F.E. – Texas

"I like the way it fits. I can hear really well with it. For the first time I can hear my granddaughter talk."
I.J. – North Dakota

"I wore it to Bingo the other night and could hear what friends were saying for a change." R. Kissling – Florida



"I can hear the TV and understand the words which I could not do with my $5,000 aid."
M. L. – California

Great fit!

Call today for your FREE catalog!

1-800-782-6316

ext. 50-301

Shop-from-home Hearing Aid Catalog

High-quality hearing aids priced at far less than the national average. **Call today for free information: 1-800-782-6316**

Ready to use In-the-Ear Hearing Aids

Custom Fit In-the-Ear Hearing Aids

Behind-the-Ear Hearing Aids

How do you save so much?

Hearing aids have never been more expensive. According to *The Hearing Review,* the average hearing aid costs more than $1,800! **Yet, luckily for you, high-quality hearing aids are available for far less from Hearing Help Express®!**

You can SAVE 80%! How do you save so much? You order from home and your hearing aids are delivered to your door. You avoid big mark-ups, long waits, and salesmen. Your low price is based on high volume and low overhead.

Improve your hearing Risk-FREE!

Improve your hearing risk-free for 45 days in your own home! Compare our hearing aids to those costing $1,000 and more. Decide which works best for you. You won't be sorry. We only sell genuine hearing aids. ***100% money-back guarantee!*** You order easily by mail from a family business with over 500,000 satisfied customers and 27 years experience selling hearing aids by mail.

SEND NO MONEY! *Clip & mail this coupon today for your free catalog!*

☑ **YES!** I would like a free shop-from-home hearing aid catalog. I understand there is no obligation and I get FREE shipping. www.HearingHelpExpress.com/50301

Dr./Mr./Mrs./Ms. _____

Address _____

City/State/Zip _____

Mail to:

Hearing Help Express • 105 North First St., Dept 50-301 • DeKalb, IL 60115-0586

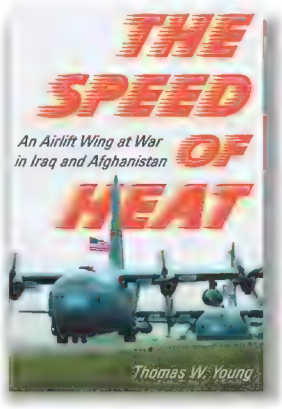
The Speed of Heat: An Airlift Wing at War in Iraq and Afghanistan

by Thomas W. Young. McFarland, 2008. 273 pp., $35.

IF A HUNDRED PEOPLE in a given military action wrote about that action, you'd get a hundred different accounts of it; so goes an old adage. Thomas W. Young, a former news reporter, flew with the 167th Airlift Wing of the West Virginia Air National Guard, a unit that operated Lockheed C-130s in Iraq and Afghanistan. To build an image of collective experience, he interviewed 70-odd members of the unit, who narrate events during their tours. The result is the opposite of those images you often see of the view of an object through the compound eye of a housefly. This is the product of 70 pairs of eyes looking in every direction and seeing things from different perspectives.

One important impression Young captures is the bond in air guard units, like this one, in which the members have a regional tie and a kinship that most describe as "family." The reader meets a wide range of characters, from the wing commander, Colonel Eric Vollmecke, to Master Sergeant John "Ratman" Ratcliffe, a loadmaster who was on his way to work at Lowe's when terrorists attacked New York City and Washington, D.C., on September 11, 2001. When he called air guard headquarters to find out what was going on, he was told to report immediately. "As soon as I got home I called Lowe's and said, 'I'm not coming in,' " says Ratcliffe. "They said, 'We've been waiting for your call. We expected not to see you.' "

While there are many different reactions to fear, each member interviewed describes the emotion in similar words. They may refer to "pucker factor" and use other expressions common in military

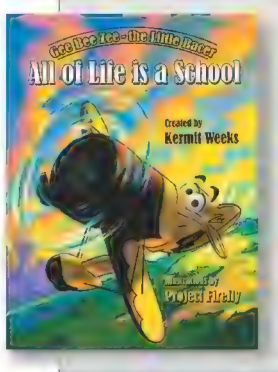


units, but not one of them denies having felt it.

This book makes the case that airlift and logistics are the heart of the military power of the United States. Combat aircraft such as fighters and bombers may get the lion's share of attention, but they are able to do their jobs only because of units like the 167th. Historians will find this book of interest, but so will those weighing a decision about signing up for the air guard (if they can get past the book's cover price). It's as complete an impression of life in that branch as can be found on contemporary bookshelves.

GEORGE C. LARSON IS THE FOUNDING EDITOR OF *AIR & SPACE/SMITHSONIAN*.

>>> At a Glance <<<

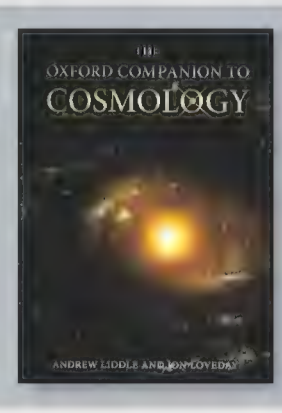


All of Life Is a School

by Kermit Weeks. KWIP Publishing, 2008. 64 pp., $19.95.

Airplane collector Kermit Weeks has created a whimsically illustrated children's book based on the collection at his Fantasy of Flight museum in Polk City, Florida.

The Oxford Companion to Cosmology



by Andrew Liddle and Jon Loveday. Oxford University Press, 2008. 343 pp., $89.95.

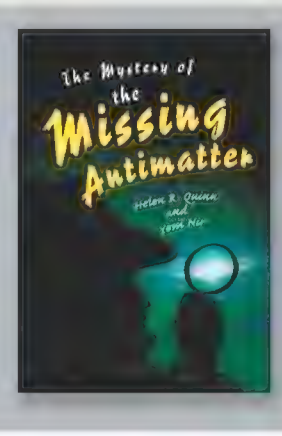
With more than 350 entries from "axions" to "zone of avoidance," this reference is a must-have for anyone who seeks to understand the universe.

Alien Volcanoes

by Rosaly M.C. Lopes and Michael W. Carroll. Johns Hopkins University Press, 2008. 150 pp., $29.95.

Numerous photographs, beautiful paintings, and carefully written text document volcanic activity across the solar system.

The Mystery of the Missing Antimatter



by Helen R. Quinn and Yossi Nir. Princeton University Press, 2008. 278 pp., $29.95.

Two physics professors have written an accessible book that explains the history of anti-matter studies and recent advances in particle physics and cosmology.

Brian Grote is a flight instructor with years aviation experience. He also writes monthly columns on subjects pertaining to aviation.

FLYBY

ARTICLE WRITTEN BY: BRIAN GROTE

Dear Brian,

I've been flying for over 20 years. My usual run is a Denver departure at 9pm, fly to Billings, on to Cheyenne and then back to Denver by 5am. I fly a King Air 350. I love my career and I pride myself on doing the best job I possibly can.

Last time out, however, I was making lots of little mistakes. I was cleared for the ILS Runway 35R into Denver, but I couldn't pick up ATIS. That's when I looked at my radios and noticed I had dialed in the wrong frequency. I glanced again and dialed in the right frequency. I continued through my checklist and set my Radar Altimeter to 5500 feet. I was ready to make my descent and start my approach. After the outer marker I glanced at my DH again and noticed that I had set my Radar Altimeter, 67 feet low. Luckily, I landed safely, bouncing the wheels just a little.

After a couple more days in the sky I could tell my eyesight was beginning to deteriorate. I knew I wouldn't be able to renew my first class medical if I didn't do anything about it. I was really worried and started asking my peers if there was anything I could do. A co-worker gave me a bottle of Claroxan™ and told me it would help me maintain my depth perception. I was skeptical at first, but tried it anyway. As it turns out, the stuff works great. The problem is, I ran out and don't know where to find more. Have you heard of this Claroxan™ stuff? Is it available in the States?

Jason, 46 – Seattle, WA

Jason,

Not only do I know of Claroxan™, it just so happens I take it everyday. Being a pilot myself, I know that perfect visual acuity is an asset none of us can afford to lose. That's why every pilot should be protecting their eyesight before it's too late.

Claroxan™ contains ingredients proven beneficial for the eyes. Among these ingredients are lutein and zeaxanthin – powerful antioxidants that have been clinically proven to protect the retina and macula and, in some cases, reverse the damaging effects of macular degeneration. These antioxidants block damaging UV rays and halt damaging free radical oxidation in the back of the eyes. They have also been clinically proven to decrease the risk of cataracts.

Claroxan™ also contains bilberry, an antioxidant known to improve night vision. Bilberry's night vision enhancing effects were first noticed in England in the early 1940's. The RAF ordered English fighter pilots to eat bilberry jam on toast figuring it would give them an advantage during night raid missions against the German Luftwaffe fighters.

Claroxan's unique proprietary formulation is completely safe, all-natural and extremely affordable. As far as ordering it, you can call them toll-free at 866.775.3937, or go to www.claroxan.com. I usually get mine within a week after ordering.

Hope this helps!
Brian

THE Himalayan CATARACT project

The Himalayan Cataract Project strives to eradicate preventable and curable blindness in the Himalayas through high-quality ophthalmic care, education, and establishment of a sustainable eye care infrastructure.

Based in Asia, at Kathmandu in Nepal, the Project is empowering local physicians to alleviate the suffering caused by blindness through unique programs including skills-transfer education, cost-recovery, research, and the creation of a world-class network of eye care facilities.

In years past, PacificHealth donated a portion of profits to HCP for development and construction of eye facilities in the Himalayas.

Visit CureBlindness.org to learn more about HCP.

CLAROXAN™ | LEADER IN VISION IMPROVEMENT

Sunlight, aging, and diet each cause damage to the retina and macula, which can lead to a decline in vision that glasses or contacts can't help. If you've experienced an increase in blurriness or have difficulty seeing details at any range, then you know how valuable sharp vision can be. What you might not know is that in the past three years, a flood of new scientific research has been done on natural vision enhancement. This medical research suggests that ingredients in Claroxan™ may help maintain and even improve your vision, while at the same time giving you added protection against many ocular diseases

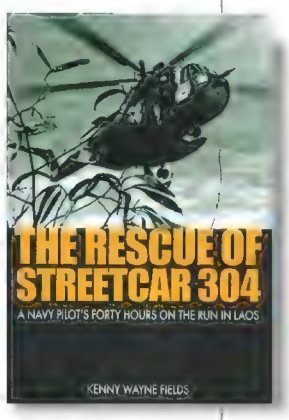
Claroxan™ may improve macular pigment density, which research shows has amazing effects on vision. By improving macular pigment density, ingredients in Claroxan™ may improve normal visual acuity, contrast sensitivity, and even glare reduction. Participants in one clinical study reported that ingredients in Claroxan™ improved their long range vision outdoors – in some cases, they were able to distinguish far away ridges up to 27 miles further than normal! Even if you have perfect vision now, Claroxan™ may help give you an edge by improving your visual reflexes and may allow you to pick up on moving objects faster than ever before.

People who count on their vision – people like pilots, hunters, military, and even pro athletes – trust Claroxan™ as the best source available for vision enhancement and protection. Claroxan™ is safe, effective, and extremely affordable. However, people with serious health concerns should consult a doctor before use.

Reviews & Previews

The Rescue of Streetcar 304: A Navy Pilot's Forty Hours on the Run in Laos

by Kenny Wayne Fields. Naval Institute Press, 2007. 384 pp., 29.95.



VIETNAM WAR books keep coming. Fortunately, the majority are excellent. The title of this book gives away the ending, but I can assure you a gripping adventure awaits. By reviewing military archives and contacting most of the airmen who risked their lives to save his, Kenny Wayne Fields has pieced together the story of his evasion.

In 1968, Fields, a young A-7 Corsair pilot, was stationed aboard the aircraft carrier USS *America* in the Gulf of Tonkin. On May 31, Fields and his wingman had an 0600 brief for their first-ever combat mission. Because of maintenance problems, however, their launch was repeatedly pushed back until the late afternoon, the very last "go" of the day. As a former U.S. Air Force fighter pilot and Vietnam vet, I found it extraordinary that the Navy would send two new guys, on their own, for their first combat mission. In the Air Force, we thought it much better to have an "old head" lead the way for at least the first few missions. (For an excellent book on Vietnam naval air doctrine, read *On Yankee Station* by John B. Nichols and Barrett Tillman.)

Fields, call sign Streetcar 304, checked in with the airborne control center, which advised him of a hot target near Tchepone in southern Laos. On his first dive-bomb run, he scored a direct hit on a river barge off-loading supplies. On his second pass, a blast from an anti-aircraft gun blew his right wing off. He quickly ejected. Fields was so low that after his parachute opened, he swung once and hit the ground. Hard. Two North Vietnamese soldiers saw him and gave chase, but he was able to lose them in the thick undergrowth.

For the next 39 hours, Fields was on the run. There were times when enemy

soldiers nearly stepped on him and times when they seemed to look right at him. Turning to prayer, Fields writes: "Now I wish I had consistently lived by the Golden Rule, and adhered to all the Ten Commandments, but I had not."

Within 40 minutes of his shoot-down, an Air Force rescue operation was in full swing. The book recounts the 189 sorties, with seven aircraft shot down or damaged, before the eventual rescue.

BOB HANSON FLEW 122 COMBAT MISSIONS IN F-4 PHANTOMS. HE IS NOW A FREELANCE WRITER LIVING IN KANSAS.

>>> Space Food <<<

IF YOU LIKE ICE CREAM and fresh strawberries, you'll probably want to try their freeze-dried versions, which the National Air and Space Museum sells in small foil pouches. Originally developed as snacks for the early Apollo lunar missions, both the strawberries and the ice cream are frozen to -40 degrees Fahrenheit and then vacuum-dried. The strawberries, which have no added sugar, are both sweet and tart, while the ice cream is surprisingly delicious (probably why it sells at the rate of some 1,500 pouches per week). The appeal of both products is the chalky, melt-in-your-mouth texture – the way space food used to be. Ice cream, $5, 3/4 oz.; strawberries, $5, 1/3 oz. To order, call the National Air and Space Museum at (202) 357-1387.

ERIC LONG

Reviews & Previews

Down to Earth: A Fighter Pilot's Experiences of Surviving Dunkirk, the Battle of Britain, Dieppe and D-Day

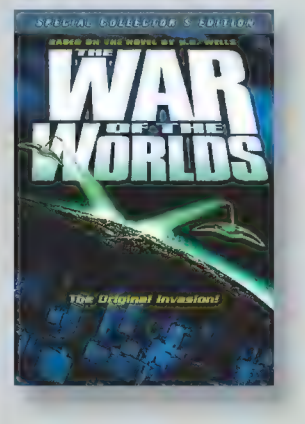
by Kenneth Butterworth McGlashan with Owen Zupp. Grub Street, 2007. 192 pp., $39.95.

KENNETH McGLASHAN entered the Royal Air Force as a cadet in 1939, training in aircraft such as Tiger Moths and the elegant silver biplane variants of the Hawker Hart. Flying a Hawker Hurricane fighter over the Dunkirk evacuation, he got shot down, the victim of a German Messerschmitt Bf 109; this was neither the first nor the last time he brushed against death.

McGlashan carries us in the cockpit through night fighter sorties, wartime airline operations, and missions in his obvious favorite: the twin-engine de Havilland Mosquito. It is our good fortune that the flier returns from war, darkness, abysmal weather, and engine failure, and that the writer Owen Zupp listens patiently and captures McGlashan's voice in a well-written narrative.

The slower, last third of the book, detailing the airman's post-war service into the Jet Age, brings the story full-circle when the author learns that his former mount has been discovered in the sand on the beach at Dunkirk. (McGlashan's Hurricane is currently being restored at Hawker Restorations Limited in Ipswich, Suffolk County, England. See "Best of the Battle of Britain," Feb./Mar. 2008.)

BOB McLEAN HAS BEEN FLYING LIGHT AIRPLANES FOR NEARLY THREE DECADES, AND IS HALF-OWNER OF A 1948 TEMCO SWIFT. HE RESTORES AIR- AND SPACECRAFT AT THE NATIONAL AIR AND SPACE MUSEUM'S PAUL E. GARBER PRESERVATION, RESTORATION AND STORAGE FACILITY IN SUITLAND, MARYLAND.



The War of the Worlds: Special Collector's Edition

DVD. Rated G. Paramount Pictures, 2005. $12.99.

I SAW *The War of the Worlds* in 1967, when it first aired on network television. Watching the movie on my family's black-and-white TV set, I was one scared five-year-old. Three years ago, Paramount released the 1953 science fiction classic in DVD format, allowing home viewers to enjoy this film adaptation of H.G. Wells' terrifying tale of murderous Martian invaders.

Nominated for three Academy Awards (it won for best special effects), *War* opens with a sequence of lush planetary paintings by noted space artist Chesley Bonestell, while the tremulous voice of a male narrator explains that Mars is a dying planet and that its residents deem Earth the best place in the solar system to relocate. The film then cuts to Corona, California, a small town outside Los Angeles, where some of the townsfolk initially welcome the extraterrestrial visitors. In the film's most famous scene, a Bible-clutching minister, reciting the 23rd Psalm, walks toward a hovering Mars craft, only to be killed by a heat ray (the first of many fiery deaths that should have stripped *War* of its G rating).

With well-paced action, good art direction, and beautiful color cinematography, the film has much to admire, including its depiction of 1950s Americana — a collection of church steeples, diners, and square dances. Airplane buffs will appreciate footage of a real Northrop YB-49 flying wing, which in *War* is assigned to drop an atom bomb on a Martian stronghold. An unintentionally funny line has the bomber's pilot saying before takeoff: "Hello tower! This is an Air Force flying wing." The naïveté continues when soldiers and civilians gathered on a hillside are warned: "Attention please. Four minutes to bomb time."

The collector's edition includes interviews with the lead actors, as well as commentary from film historians on *War*'s exalted place in the history of science fiction cinema.

DIANE TEDESCHI IS AN *AIR & SPACE* ASSOCIATE EDITOR.

Credits

"I Have a Flameout." Duke Woodhull says that flying the U-2 was the high point of his 30-year Air Force career.

Zeppo's Gizmo. When not screening Marx Brothers comedies, engineer Nick D'Alto builds replica aircraft for Long Island's Cradle of Aviation Museum.

Finding Apollo. Tony Reichhardt is a senior editor at *Air & Space/ Smithsonian*.

Live and Let Fly. A senior researcher for *National Geographic* magazine, David Lande wrote "Music to Fly By" (Dec. 2007/Jan. 2008). He has written several aviation books.

Restoration: Cleaning a Carrier. Frequent contributor Phil Scott is the author of *Hemingway's Hurricane* (McGraw-Hill, 2005).

The Disorient Express. Private pilot Tom LeCompte is a Cambridge, Massachusetts-based freelance writer.

Big Idea. Kara Platoni freelances from the San Francisco Bay Area. This is her first feature for *Air & Space*.

Control the Air. Ed Darack is a freelance writer and photographer whose book about Marines fighting in Afghanistan, *Victory Point*, will be published in April 2009 by Berkley Caliber.

Mission: Possible. Anatoly Zak wrote "Lunar Clipper," about future tourist flights around the moon in Russian Soyuz vehicles, for the Sept. 2007 issue.

Portrait of the Enemy. The author of eight novels, Robin White is now writing a guide to doing business in a post-petroleum world.

Hard Hat Zone. Roger A. Mola is a researcher at *Air & Space*.

Forecast

IN THE WINGS AND ON THE WEB...

IN THE NEXT ISSUE

BOEING'S DREAM TEAM
Your airliner is on the fritz. Who do you call? The best roadside service on the planet.

THE LAST TO DIE
Three days after Japan agreed to a cease-fire, the U.S. 20th Reconnaissance Squadron stumbled into the final air combat of World War II.

BRING BACK THE BRUTE
Re-creating the Gee Bee, one of the most notorious racers ever flown.

COMING TO *www.airspacemag.com*

NIGHT AT THE MUSEUM The sequel to the 2006 blockbuster was recently filmed at the National Air and Space Museum; read tales from the making of *Night at the Museum II: Escape From the Smithsonian*.

HUMANS VS. ROBOTS in space: Are astronauts obsolete?

EARLY CHINESE AVIATORS Profiles honoring the host nation of the 29th Olympiad.

NASM (SI 85 3319-P)

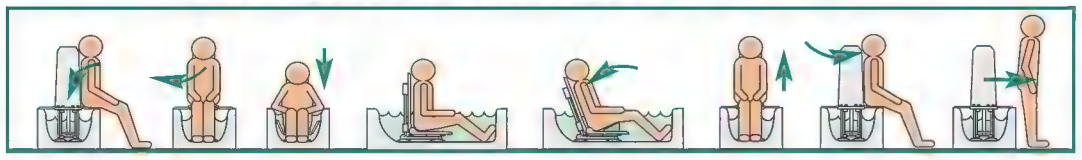
Pioneering aviator – and former silent film star – Ya-Ching Lee (far right) raised funds for United China Relief during World War II.

HAPPY 50TH, NASA!
From men on the moon to robots on Mars, memorable photographs from NASA's first 50 years of exploration.

Space: A Journey to Our Future
A brief tour of the traveling museum exhibition highlighting NASA's current projects.

NASA's Greatest Aeronautical Hits
Achievements in NASA's first "A."

Introducing
The Neptune Reclining Bath Lift



- *Reclines for a comfortable, relaxing bath*
- *Charges overnight*
- *Battery operated*
- *Wide seat*
- *Extra-high backrest*
- *Folds for portability*
- *Chair raises up to 17″ and lowers to 3″*
- *Transfer flaps for added stability*

Powerful NiCad Battery

Includes waterproof remote!

Innovative European technology allows anyone with mobility issues to take a bath safely.

It's a fact, Americans are living longer than ever. Medical technology has increased our life expectancy, but it hasn't necessarily improved our quality of life. For many people, living longer doesn't mean living better, as they lose their independence, dignity, and quality of life. Many have to move out of the home they love because they can no longer do simple things… like taking a bath… without someone's help. Now, an innovative company has used the latest technology to help millions of Americans stay safe, stay in their home, and enjoy a better quality of life. It's called the Neptune™ Reclining Bath Lift, and it's changing the way older Americans live.

Remember when taking a bath was something you looked forward to, not something you avoided?

Revolutionary Technology…A Simple Solution. The Neptune™ Reclining Bath Lift is designed to help millions enjoy one of life's simple pleasures… a warm, comfortable bath. Using a powerful, 12-volt NiCad battery, its powerful motor raises and lowers the seat so that anyone, regardless of mobility issues, can get in the tub easily, comfortably, and without the fear of slipping and falling. There's no danger of being shocked because the remote is waterproof, double sealed, and detaches from the chair so you can take it to another room for charging if you wish. The battery can be fully charged overnight and, once charged, provides enough power for 7 up/down cycles. There's an indicator light that lets you know the battery needs to be charged, and if there is not enough power for a full up/down cycle, the seat will not go down.

Sit Back…or Lie Back…and Relax. One of the special features of this remarkable product is that it allows you to bathe in a reclining position. Once you lower yourself into the tub, you simply push the button and the back reclines.

Call Today…and Try Neptune With Our Exclusive In-Home Trial. Are you tired of taking sponge baths at the sink, sitting in the shower, or… worse yet having a friend, relative, or caregiver help you take a bath? Why not try Neptune in your own home and see for yourself. If you are not satisfied for any reason, simply return it within 90 days for a full refund of the product purchase price less shipping and handling. Don't wait, call today, our product experts are standing by to answer any questions you have.

Neptune™ Reclining Bath Lift

Item # ZR-5247

Call now for our lowest price!

3"- 17"H x 18.75"L x 14"W.

300 lb. weight capacity.

Please mention promotional code 36456.

For fastest service, call toll-free 24 hours a day

1-877-881-8324

We accept all major credit cards, or if you choose, you can pay by check over the phone. To order by mail, please call for details.

firstSTREET® for Boomers and Beyond®

1998 Ruffin Mill Road
Colonial Heights, VA 23834

www.firststreetonline.com

*Introducing the world's simplest cell phone experience – with service as low as $10 a month**

It doesn't play games, take pictures, NEW or give you the weather

No Contract

The Jitterbug® developed with Samsung®.
It's the cell phone that's changing all the rules.

For people like me, who want a cell phone that's easy to use. Over the years, cell phones have become smaller and smaller with so many complicated features. They are harder to program and harder to use. But the Jitterbug® cell phone has simplified everything, so it's not only easy to use, it's easy to try. No crowded malls, no waiting in line, no confusing sales people, or complicated plans. Affordable and convenient cell phone service is only a toll-free phone call away.

Questions about Jitterbug? Try our pre-recorded Jitterbug Toll-Free Hotline **1-866-427-1479**

The new Jitterbug® cell phone makes calling simple!

- Large, bright, easy to see display and buttons
- Comes pre-programmed and ready to use right out of the box
- No contract required
- An operator is always available to help you, and will call you by name
- Push "Yes" to call directly from your personal phone list
- Soft ear cushion and louder volume for better sound quality
- Separate Volume Up/Down button on cover of phone
- Hearing aid compatible
- Familiar dial tone confirms service (no other cell phone has this)
- Service as low as $10 a month*
- Access help wherever you go

Why pay for minutes you'll never use!	Simple 30 Plan†	Simple 60 Plan†
Monthly Price	$15.00	$20.00
Included Minutes/Month	30	60
Operator Assistance	24/7	24/7
911 Access	FREE	FREE
Long Distance Calls	No add'l charge	No add'l charge
Nationwide Coverage††	Yes	Yes
Trial Period	30 days	30 days

Available in a simple 12-button Dial phone and an even simpler 3-button OneTouch phone for easy access to the operator, the number of your choice, and 911.

12-button Dial Phone available in Graphite and White.

Service as low as $10 a month and a friendly 30-day return policy**. If you've ever wanted the security and convenience of a cell phone, but never wanted the fancy features and minutes you don't need… Jitterbug® is for you. Like me, you'll soon be telling your friends about Jitterbug®. Call now.

jitterbug®
brought to you by firstSTREET for Boomers and Beyond®
1998 Ruffin Mill Road
Colonial Heights, VA 23834

See hundreds of other innovative products for *Boomers and Beyond® at www.firstSTREETonline.com*
Call 1-800-704-1211 for a Free Catalog.

Jitterbug® Cell Phone Item# BU-4722

Call now for our lowest price.
Please mention promotional code 36455.

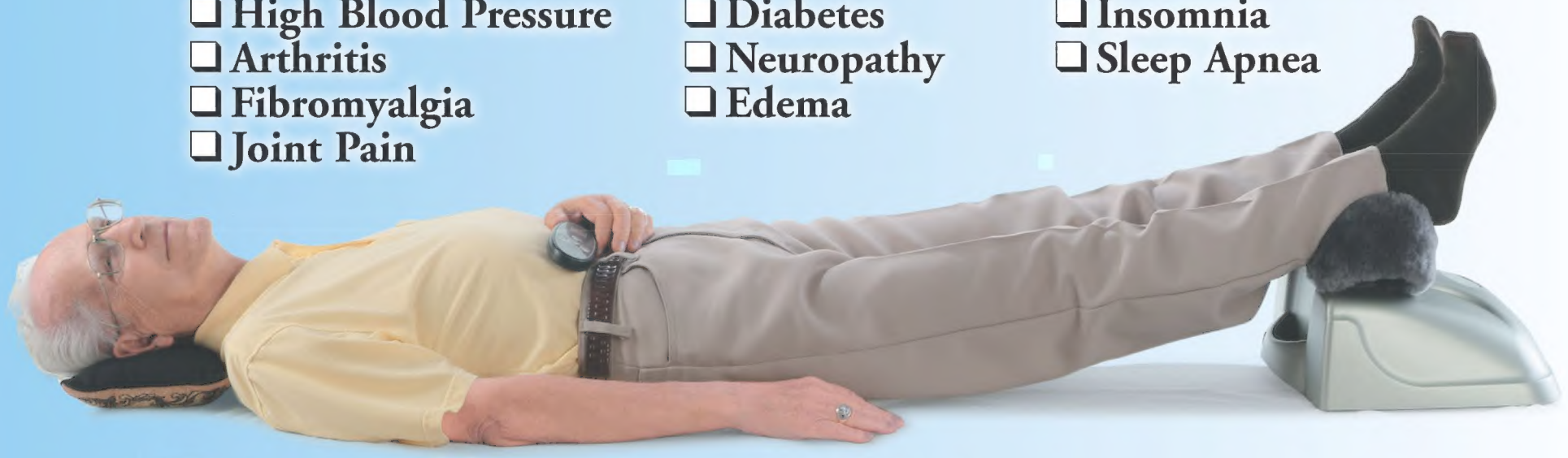
1-866-540-0297

www.jitterbugdirect.com

IMPORTANT CONSUMER INFORMATION: Subject to Customer Agreement, select calling plans, and credit approval. Other charges and restrictions may apply. Screen images simulated. Coverage and service not available everywhere. Copyright © GreatCall, Inc. Jitterbug and GreatCall are trademarks of GreatCall, Inc. Samsung is a registered trademark of Samsung Electronics America, Inc and its related entities. *Not including government taxes, assessment surcharges, and set-up fee. **Applies to phone and monthly service charges only, provided call time usage is less than 30 minutes and phone is in like-new condition. Usage charges may apply. †All plans require the purchase of a Jitterbug phone. In addition, there is a one time set up fee of $35. ††Jitterbug will work almost everywhere in the U.S. where cellular service is available from most of the major carriers.

If you suffer from

- ❑ Stress
- ❑ Headaches
- ❑ High Blood Pressure
- ❑ Arthritis
- ❑ Fibromyalgia
- ❑ Joint Pain
- ❑ Constipation
- ❑ Back Pain
- ❑ Diabetes
- ❑ Neuropathy
- ❑ Edema
- ❑ Stiff Muscles
- ❑ Poor Circulation
- ❑ Insomnia
- ❑ Sleep Apnea



You will enjoy using the Exerciser 2000 *Elite*™

Receive some of the benefits of aerobic exercise without stress or impact on the joints!

Relaxation of the back muscles

Oxygenation of the blood

Increased mobility

Increase circulation throughout the body

Helps relieve stiffness from head to toe

These statements have not been evaluated by the FDA.
Not intended to treat, cure or prevent any diseases.

How Does the Exerciser 2000 Elite™ Work?

Enjoy the benefits of passive exercise—just lie down, place your ankles on the ankle rest and let the machine do the work.

When you turn the machine on, it creates a 2 inch, right to left movement that gently moves the body back and forth.

This gentle swinging motion cycles up through the whole body, creating an exercise movement without stress or impact on the joints.

Don't be fooled by cheap imitations

Features

- Weighs only 15 pounds
- 15" wide x 13.5" deep x 9.5" high
- ISO-9001 CERTIFIED
- FDA Class 1 Registered
- ETL Approval
- 5-speed operation
- 2 pre-programmed selections —one for relaxation and one for energizing
- Heavy duty, high torque DC motor
- Wide cushioned ankle rest
- 16 minute digital timer with safety shut-off
- **2 year parts and labor warranty**

What people are saying about the Exerciser 2000 Elite™

After using the Exerciser 2000 Elite™ twice a day for one week the swelling in my ankles went away. It has also helped my breathing, as I can get out and walk without having to stop and catch my breath! Thank you. —*Shirley H., Florida*

After having a stroke, I could no longer exercise the way I used to. As a result, I developed edema. A friend of mine introduced me to the Exerciser 2000 Elite™. I loved it and I purchased one for myself. After using the machine daily for a few weeks, my symptoms of edema were completely gone. I now use the machine twice a day for 16 minutes each time on speed 3. What a wonderful way to exercise.—*Robert M.*

I am in my late 80's and have diabetes. The first thing I noticed when I started using my machine was that my feet were warm when I went to bed. They were always ice cold before. Because one of my problems is poor circulation, I use the machine three times a day for 10 minutes each; in the morning, late afternoon and just before bed. I almost forgot to mention that I have not been able to lift my arms above my head. Now I can do it. You think that's no big deal until you can't do it anymore. —*Ralph K.*

As a Chiropractor, I would like to say that the Exerciser 2000 Elite™ enables people to benefit themselves at home. It is a valuable asset in moving lymph fluid, oxygenating the blood, increasing immune system function, maintaining mobility in the spine, and additionally freeing up a spine that has become stiff and arthritic. —*Garry Gorsuch, D.C.*

I love using the Exerciser 2000 Elite™ after my morning workout. It is an excellent way to cool down and it helps to start my day off right.—*Deanna C., Kansas*

My husband and I have been into natural products all of our lives but nothing has ever affected us like the Exerciser 2000 Elite™. My husband is 72 and delivers flowers. He carries 5 gallon buckets of water. Since using the machine, his back hasn't hurt him at all. My hips would hurt if I stood too long and I would get weak and have to sit down. Now I can walk and sit as long as I want. I don't take pain medication anymore. In the morning, when I get out of bed I'm not stiff anymore. At 65, wow, this is great! Thank you for offering such a great machine. We are going to tell everyone we know about it. —*Cheryl J.*

The ad I saw almost sounded "too good to be true". With your no risk money back guarantee I figured I had nothing to lose so I purchased the machine… and boy, am I glad I did! I am 75 years old and suffer from sciatica, which makes my back and legs tighten up and causes numbness. I was taking 8-10 Aleve™ every day. After using the machine for only 4 minutes, I noticed my lower back loosening up. Since I have been using the machine I haven't taken any pain pills and have been pain free. My sciatica is not giving me problems anymore and my body stays loosened up. I have also had a snoring problem for quite some time, however, since using the machine my snoring has subsided. My wife is so excited! I cannot tell you how much this machine has turned my life around. —*C. Cummings*

I have had constipation problems for over 25 years. Since I have been using the Exerciser 2000 Elite™ I have been regular every day and have begun to lose weight. This is truly a blessing and is so easy to use. —*Jeannie*

I had suffered with sleep apnea for many years and had been taking drugs for it. I was told I would have to use a breathing apparatus. In the meantime, I was introduced to the Exerciser 2000 Elite™ and decided to purchase one. Within two weeks, I was sleeping more deeply and restfully than ever before. —*David B.*

~~Retail Price:~~
~~$464.95~~

✔ *Use Code E200 when ordering by phone or website and receive a promotional price of* **$359.95** *and FREE shipping in the Continental United States.*

Save $90.00 on demo units when available.

✔ *90 Day No Risk Money Back Guarantee—You have nothing to lose. If you are not completely satisfied, you can return it for a full refund. We provide a FREE return shipping label for your convenience.*

1-800-748-7172
www.clarkenterprises2000.com

Clark Enterprises 2000 Inc.
The "Helping People Feel Better" Company
240 Berg Road, Salina, KS 67401

Hits and Missiles

EARLY EXPERIMENTAL airplanes were often paired with heroes like Chuck Yeager and Scott Crossfield, but that pattern was broken after the X-6, a huge Convair B-36 bomber that was modified for nuclear propulsion research and meant to be flown by a crew of five. The X-plane that followed, the X-7, was its opposite in every way: tiny and very fast instead of gigantic and lumbering. And it carried nary a human.

Lockheed built it and surprised the establishment by choosing an unconventional way to attain speeds well above Mach 1: Instead of wing sweep, the company used a unique wing with a razor-thin airfoil. The trapezoidal shapes of the stubby wings and tail would show up later in the company's XF-104 fighter prototype, but the X-7's job was not warfare but pure research—in this case, into high-speed ramjets. It was a minimalistic vehicle: just a long, slender fuselage ending in a sharp spike. After its flight was over, the vehicle descended under a parachute nose-first, and the spike would dig into the earth. Like a lawn dart, it could be pulled out and re-used. A test ramjet was slung beneath the aircraft in a configuration that would have made conventional landing gear impractical. The combination looked like a balsa glider carrying some weird round phone booth.

To test the ramjets, Lockheed had to boost the X-7 to the high speeds that such engines need for igniting. The company had a good off-the-shelf solid rocket booster, the XC202-C3, which the Allegany Ballistics Laboratory in Pinto, West Virginia, had developed in wartime secrecy under the oversight of George Washington University of Washington, D.C. With its 100,000-plus pounds of push, the rocket's task was to get moving through the air fast enough so that the ramjet's carefully shaped intake would compress the incoming flow the way the rotating compressor does on a turbojet. Having no turbomachinery, ramjets work aerodynamically: Their intakes convert the inlet air's energy from velocity to pressure, after which fuel can be added to the air flow and ignited. Most ramjets have internal surfaces to help maintain the flame once the engine starts. In some respects, ramjets can be thought of as rockets that use air for their oxidizer.

Because they were so simple and cheap, ramjets found a ready market powering expendable target drones. But they were also loud fuel hogs that only now are making a minor comeback as a way of extending the range of missiles.

The X-7 once held the speed record for an air-breathing aircraft—Mach 4.31 (almost 2,900 mph)—but NASA's more recent scramjet experiments easily topped that mark.

The National Aeronautic Association is giving UAVs their due, by recording their achievements in a category of their own in the sporting code that governs record attempts. In the NAA's archives, for example, you'll find that a Northrop Grumman RQ-4A Global Hawk flew 8,214.44 miles from Edwards Air Force Base in California to Edinburgh Royal Australian Air Force base on April 23, 2001.

GEORGE C. LARSON, MEMBER, NAA

The X-7 (left) could be plucked from the ground and remounted on its B-29 carrier (below).

LOCKHEED MARTIN (2)